“DESIGN OF ULTRAWIDE BAND ANTENNA BY USING DEFECTED GROUND STRUCTURE”

DISSERTATION-II REPORT

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CERTIFICATE

This is to certify that (Megha) bearing Registration no. 11207135 has completed objective formulation of thesis titled, “design of ultra wide band by using defected ground structure” under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the thesis has ever been submitted for any other degree at any University.

The thesis is fit for submission and the partial fulfillment of the conditions for the award of Masters of Technology.

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DECLARATION

I, Megha, student of B-TECH M-TECH (Dual degree) under Department of electronic and communication department of Lovely Professional University, Punjab, hereby declare that all the information furnished in this thesis report is based on my own intensive research and is genuine.

This thesis does not, to the best of my knowledge, contain part of my work which has been submitted for the award of my degree either of this university or any other university without proper citation.

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ABSTRACT

Design of ultra-wide antenna by using defected ground structure helps in enhancement of gain and bandwidth parameter of the patch antenna. In this design a new type of antenna is made in which its ground plane is defected by adding two symmetrical U-shaped slots etched from it. At the front side of substrate defected ground plane with the defects in it is made and at the back side radiating patch which is of Y-shaped with a microstrip feed-line is made. By using defected ground structure return-loss parameter, gain and bandwidth is improved. The above design of antenna is applicable for WIMAX, WLAN, satellite and X-band applications.

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CHAPTER-I

ANTENNA THEORY

1.1 INTRODUCTION

As we live in 21st century, which is called "century of science and technology". Communication between two people is only possible through this new and emerging technology. In our day to day life electronic components are manufactured at a very fast rate in order to meet the growing demands of people. The person sitting at one place can communicate with any other person residing in different location. Every device or communicating media consists of an antenna which is used to receive and transmit signals. Without this antenna the communication is not possible. Antenna becomes the most important part of our life. All our day to day activities can not be possible without antenna. Smart phones which change our life completely also consist of an antenna by which communication is possible. Antenna plays a major role in laptops, GPS devices, transceivers, dongles, WIMAX, airplanes, space vehicle navigation and many other devices. The satellites which transmit and receive information can also possible with the help of antenna. An antenna design is considered to be good when it will not degrade the performance of an antenna or its parameters. The IEEE standard definition of antenna is defined as a means of radiating and receiving radio waves. In other words, it is the transitional structure between free space and guiding media. The media which is used to transport electromagnetic energy from transmitting end to antenna or from antenna to receiver end is called guiding media. Sometimes it takes the shape of a coaxial line or a hollow pipe. An ideal antenna is that type of antenna which will radiate all its power to the transmitter side in any direction. But in real scenario, this ideal nature cannot be fulfilled but we can approach it closely. Antenna can be categorized into two parts- receiving and transmitting antenna. Receiving antenna is taking the energy and delivers alternating current to electronic instruments and Transmitting antenna uses alternating current from electronic devices and generates an RF field. Under ideal conditions, energy exhibited by transmitting end must be transferred to radiation resistance. But in practical scenario there are conduction and dielectric losses due to lossless nature of transmission line and antenna, as well as due to mismatch between transmission line and antenna. Neglecting all these losses, antenna can attain maximum power under conjugate matching condition. By properly selection of low loss lines and by reducing the loss resistance somewhat the losses of an antenna can be minimized Antenna is used to receive and transmit energy and it is used to optimize the radiating power energy in some directions and inhibit it in other directions. Therefore the antenna can behave as a directional device in combination to probing device.

1.2 TYPES OF ANTENNA

1) WIRE ANTENNA: This antenna can be seen in all places like on automobiles, ships, aircraft, spacecraft, and buildings. Different shapes of wire antenna are available such as straight wire (dipole), helix, loop etc. The antenna which is in loop form can take any shape such as the shape of a rectangle, square, ellipse or any other geometry.

2) APERTURE ANTENNA: These antennas are increase in demand due to more sophisticated technology and utilization of higher frequencies. These antennas are considered to be very advantageous for spacecraft and aircraft applications because they can be attached on the outer body as well as on inner covering of aircraft and spacecraft. To protect the outer body from hazardous surroundings the outer body can be covered with any dielectric material.

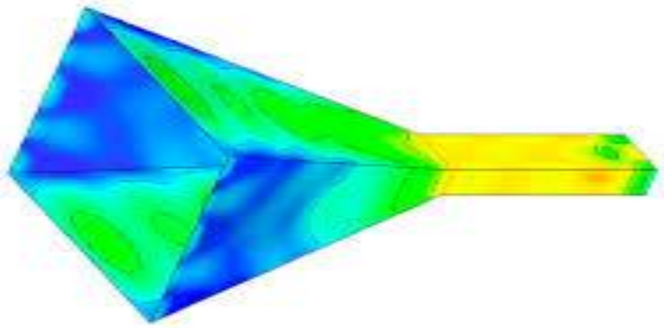

Fig 1.1 Aperture antenna

3) MICROSTRIP PATCH ANTENNA: These antennas comprises of a metallic patch on a dielectric substrate with a ground layer on one side. The metallic patch antenna may take any shape like circular, rectangular etc. These antennas are considered to be low in profile, highly compatible, simple in structure, small size and low in cost as compared to other antennas and also applicable to planar and non-planar surfaces. They are very much adapted in frequency, polarization, radiation pattern and impedance. These can be attached on the outer as well as inner surface of high performance aircraft, spacecraft, satellites, missiles, cars and even in hand held devices. These antennas can also be applicable for industrial and commercial use.

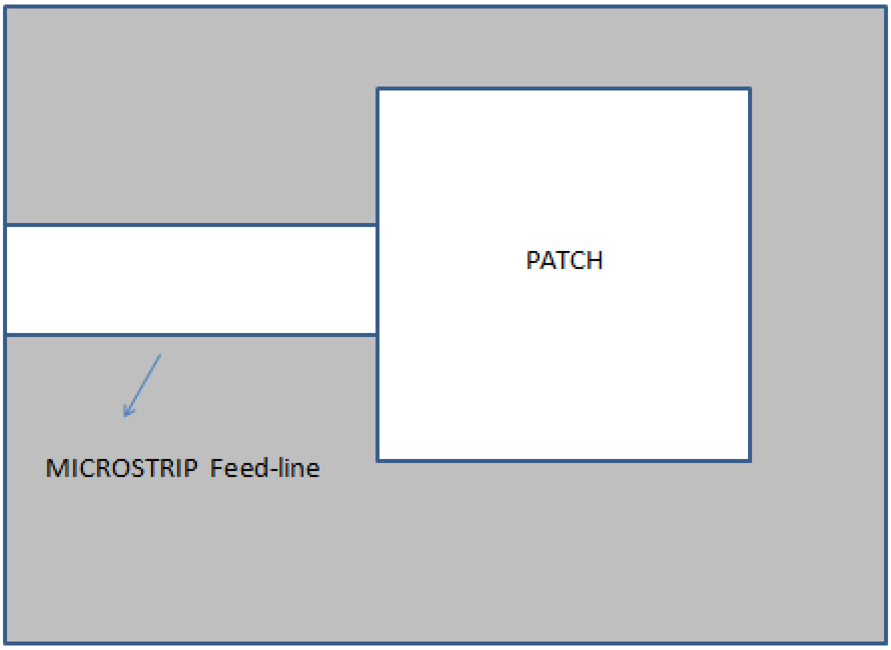

Fig 1.2 Rectangular Microstrip antenna [3]

4) ARRAY ANTENNAS: Sometimes the radiation characteristics are not achieved by a single element in most of the applications. In such cases it may be possible that combination of radiating elements in an arrangement like in an electrical and geometrical arrangement will fulfil the criteria of desired radiation characteristics. The array is arranged in such a way that radiation from all the elements is added up to attain the maximum or minimum radiation characteristics in a given direction depending upon the requirement. An array may be sometimes defined as integration or combination of elements installed on a continuous structure or it is used for an arrangement in which individual elements are separable.

5) REFLECTOR ANTENNAS: These antennas have been constructed with aperture diameter as much as 305m. To transmit and receive signals over a long distance these antennas are needed with high gain criteria. The parabolic antenna is one type of reflector antenna which is required to communicate over longer distances. These sophisticated forms of antenna are required so that we can transmit and receive signals over a larger distance.

6) LENS ANTENNA: To prevent the antenna from radiating in all the directions, this type of antenna is used to collect or focus the incident divergent energy in a given direction. By choosing suitable material of lens and by proper shaping the geometrical configuration, these antennas can convert different forms of incident energy into plane waves. These antennas should work at high frequencies like the parabolic reflector antenna can do. They are lower in weight and in dimension at lower frequencies. They are categorised on the basis of the material and their geometrical configuration or on the basis of material from which they are made.

7) DIPOLE ANTENNA: The simplest form of antenna is the dipole antenna which is used in radio communication. It is a straight electrical conductor which measures half wavelength from one end to another and connected to the centre of radio frequency. It can be oriented vertically or horizontally. It is fed with a balanced, parallel wire RF transmission line.

TYPES OF ANTENNA DEPENDING UPON RADIATION PATTERN:

1) ISOTROPIC ANTENNA: It is defined as "a hypothetical lossless antenna having equal radiation in all directions." But in reality it is considered to be ideal in nature and the one which is not realizable in a physical manner, and sometimes it is taken as a source antenna to express all the properties of an antenna.

2) OMNIDIRECTIONAL ANTENNA: It is that form of antenna which is as "one having an essentially no directional pattern in a given plane (in azimuthally plane) and a directional pattern in any orthogonal plane (in elevation plane)". So it is considered to be one type of directional antenna.

3) DIRECTIONAL ANTENNA: It is that form of antenna which is as the "one having the feature of transmitting and receiving electromagnetic waves more effectively and efficiently in some directions and suppress it in others. This antenna is considered to have its maximum directivity and it is greater than that of a half-wave dipole.

1.3 CHARACTERISTICS OF AN ANTENNA: To analyze the performance of an antenna, various parameters and their knowledge is necessary. From all the parameters, some are related to each other so we do not specify all the parameters for the complete description of the performance of the antenna and for this purpose; we need to study the characteristics of an antenna.

1.3.1 RADIATION PATTERN: It is expressed as "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. It is determined in the far field region and is represented as a function of directional coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity, phase or polarization."It is 2-dimensional or 3-dimensional spatial variation of transmitted energy as a function related to position of any random user along any path or surface of any radius. A path of electric field or magnetic field which is received at a fixed radius is defined as the amplitude field pattern; whereas a graph related to spatial distribution of the power density along a fixed radius is called as an amplitude power pattern.

1.3.1.a RADIATION POWER LOBES: There are major types of a radiation pattern which are called as lobes and it can be further classified into major lobes, minor lobes, side lobes and back lobes. A radiation lobe is defined as a "portion of radiation pattern which is surrounded by regions of weak radiation intensity." Some are of greater or others are of lower radiation intensity but all are termed as lobes.

1) MAJOR LOBE: It is also called as main lobe. It is classified as "the radiation lobe containing the direction of maximum radiation". Or we can say that major lobe is that one which is radiating towards the $\theta=0$ direction. For ex: Existence of more than one major lobe is seen in split beam antenna.

2) MINOR LOBE: It is any other type of lobe except a major lobe. Or we can say that all the lobes except the major lobe. They represent radiation pattern not in desired directions. For an efficient antenna, minor lobes are not required so they should be minimized.

3) SIDE LOBE: It is defined as the "radiation lobe in any direction other than the intended lobe." It has the same direction as that of a major lobe and it is neighbouring node to the main lobe. Side lobe is considered to be the longest of the minor lobes.

4) BACK LOBE: It is defined as "a radiation lobe whose axis makes an angle of 180^0 with respect to beam of antenna ". It is considered to be part of a minor lobe and it lies in an opposite direction to that of main lobe.

SOME OTHER PARAMETERS OF AN ANTENNA-

1) BEAM-WIDTH: It is defined as a parameter which is associated with the antenna pattern. It is also defined as the maximum angular separation between the two same beams on the opposite side of antenna pattern. It is an important figure of merit and there is a trade off between beam-width and side lobe level; with the increase in beam-width there is a decrease in the side lobe level.

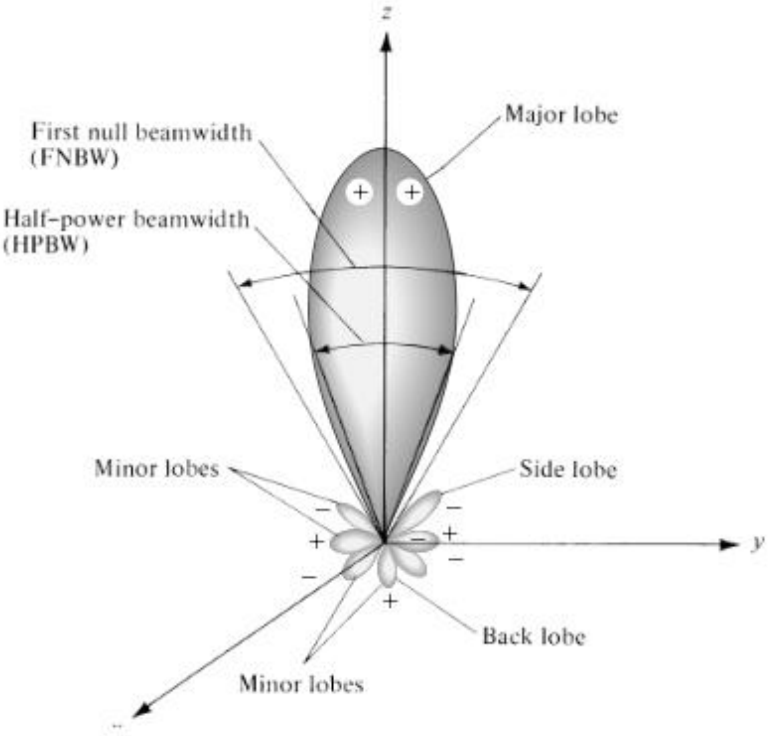

Fig1.2 Radiation pattern showing the lobes [3]

a) Half power beam-width (HPBW): It is defined as a" the angle between the two directions in which the radiation intensity is one half of the beam which contains the same direction of that of a beam."

b) First null beam-width (FNBW): the angular separation between the first nulls of the antenna pattern is defined as first null beam-width.

$$\text{HPBW} = \frac{\text{FNBW}}{2} \qquad - \ (1)$$

2) DIRECTIVITY: It is defined as "the ratio of radiation intensity in a given direction from the antenna to the radiation intensity averaged over all the directions." Mathematically it can be expressed as "total power radiated by the antenna divided by 4π which is also called as average radiation intensity. If the direction is not mentioned, then it will consider the direction of maximum radiation intensity. The direction of a non-isotropic source is defined as ratio of the radiation intensity in a particular direction over that of an isotropic source.

$$D = \frac{U}{U_O} = 4\pi \frac{U}{P_{rad}} \qquad - \ (2)$$

Table1.1: Various types of an antenna and their Directivity [6]

ANTENNA TYPE	DIRECTIVITY (dB)
Half wave dipole antenna	2.15
Microstrip antenna	5 -8
Horn antenna	10 - 20
Dish antenna	20 - 40
Short wave dipole antenna	1.76

So we should choose an antenna with a specific directivity depending upon the application for which it is used. Antenna which needs to radiate in a particular direction must have high directivity whereas antenna which needs to radiate in all the directions must have low directivity. As an isotropic source transmits equal power distribution in all the directions, therefore its directivity is unity.

3) GAIN: It is defined as "the ratio of intensity in a given direction, to the radiation intensity in a given direction to the radiation intensity that would be obtained if the power accepted by antenna were radiated isotropic ally".

Mathematically gain can be expressed as-

$$\text{Gain} = \frac{4\pi U(\theta,\varphi)}{P_{inc}} \qquad - (3)$$

When the direction is not mentioned, the gain takes the direction of maximum radiation.

Losses like impedance mismatch i.e. Reflection mismatch and polarization mismatch does not include in gain calculation.

4) VSWR (voltage standing wave ratio): It can be expressed as a quantity that how much power is reflected or transmitted by antenna. A minimum value of VSWR shows that all the incident power is transmitted to antenna and reflections are usually not considered.

5) BANDWIDTH: is expressed as “the range of frequencies within which the performance of antenna, with respect to some characteristics is defined.” It may be specified in terms of VSWR or fractional bandwidth (FBW). It is defined as highest minus lowest frequency divided by centre frequency. The quality factor (Q) is also related with antenna (higher the Q, lower is the bandwidth and vice -versa).

Table1.2: Bandwidth of some common antenna

ANTENNA	CENTRAL FREQUENCY	FREQUENCY SPECTRUM	FRACTIONAL BANDWIDTH
Patch antenna	1000MHz	985-1015 MHz	0.03
Horn antenna	1000MHz	154-1848 MHz	1.69
Spiral antenna	1000MHz	95-1900MHz	0.08
Dipole antenna	1000MHz	960-1040MHz	1.81

6) RADIATION INTENSITY: It is expressed as” the power radiated from an antenna per unit solid angle.” It is considered as a far-field parameter and mostly it can be attained by multiplying the radiation density by square of distance.

In equation form, it can written as

$$U = r^2 \times P_{rad} \quad - \quad (4)$$

Where, U= radiation intensity (W/unit solid angle)

P_{rad} = radiation density (W/m^2)

The total power is attained by integrating the radiation intensity, over the solid angle of 4pi. Therefore for an isotropic source, U will be independent of θ and φ respectively.

$$P_{rad} = \oint U d\varphi = \iint_0^{2\pi} U sin\theta d\theta d\emptyset \quad - (5)$$

Or For an isotropic source radiation intensity can be expressed as

$$U_O = \frac{P_{rad}}{4\pi} \quad - (6)$$

7) FIELD REGIONS: There are 3 field regions in an antenna first is reactive near-field region, second is radiating near-field region (Fresnel region) and third is far-field (Fraun-hofer) region. Each field is getting the responsibility of recognizing the field structure in one region only.

a) Reactive near-field region: It is determined as that area of near-field region where reactive field predominate and this region is surrounded by antenna. For most of applications, external boundary is taken to be at a minimum distance from the surface of antenna.

b) Radiating near-field region: It is determined as "that region of field between the reactive near field and far-field region wherein radiation field exist and angular field distribution is depending upon the distance from the antenna". The existence of this region is not there if the antenna has a maximum dimension as compared to the wavelength of the antenna. This region is called as the Fresnel region when the antenna is placed at infinity. The internal boundary usually takes the distance of $R>=0.62\sqrt{}D^3/\lambda$ external boundary takes the distance of $R<2D^2/\lambda$. In this region, the field pattern is a function related to radial distance and the radial field component. This field consists of a smooth pattern and it will begin to form lobes. The field pattern is more spread out and nearly uniform, with very less variations.

c) Far-field region: It is determined as the portion of the field of an antenna wherein angular field is independent of distance from the antenna. This region is taken to be at a distance which is greater than $2D^2/\lambda$ when antenna has a maximum dimension D. In this region, the field components are transverse in nature and angular distribution is not dependent on the radial distance. The internal boundary usually takes the distance of ($R=2D^2/\lambda$) and external boundary should be placed at infinity. If the antenna is centred at infinity then this region is known as the Fraun-hofer region. In this far-field region, the well formed pattern is there which is comprised of few minor lobes and one or more major lobe.

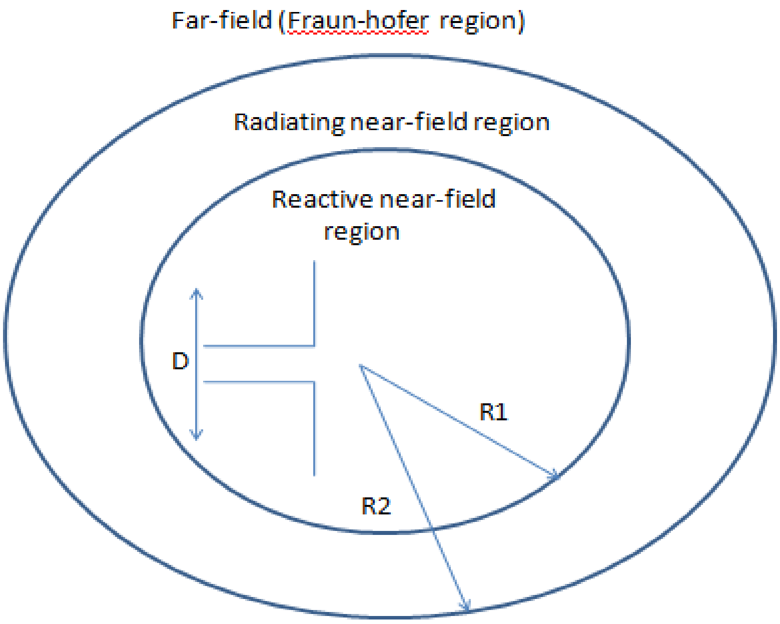

Fig1.3. Field regions [3]

CHAPTER II

TERMINOLOGY

1) Defected ground structure: It is basically a defect in the ground layer which is taken as an approximation of an infinitely dielectric material. The ground plane of a patch antenna is modified to enhance the parameters of an antenna called defected ground structure.

2) Bandwidth: is defined as "the range of frequencies within which the performance of antenna, with respect to some characteristics is defined".

3) Gain: It is defined as "the ratio of intensity in a given direction, to the radiation intensity in a given direction to the radiation intensity that would be obtained if the power accepted by antenna were radiated isotropic ally".

4) Voltage standing wave ratio (VSWR): It is defined as a parameter that measures how well the system is matched or we can say that it is a function of reflection coefficient which also describes the amount of power reflected by antenna.

5) Return-loss: It is defined as the quantity of power dissipated as a result of impedance mismatch between feed-line and load. For an ideal antenna return loss should be as low as possible.

6) Radiation pattern: It is expressed as "a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates.

CHAPTER-III

3.1 INTRODUCTION TO PATCH ANTENNA

In antenna design size, weight, cost, performance are important factors which is taken into consideration then there these low-profile antenna is useful. This antenna is used for the purpose of enriched performance of aircraft, spacecraft and missile applications .Now-a-days they are preferred in government and commercial institutions like in mobile handsets, radio and in wireless communication. The features of these antennas are low in profile, easily attached to planar and non-planar surfaces, simple, inexpensive and robust in nature. These antennas are much compatible as compared to other designs in relation to frequency, polarization and impedance. But in some applications, where there is requirement of less bandwidth such as in security of government system, these patch antennas come into picture.

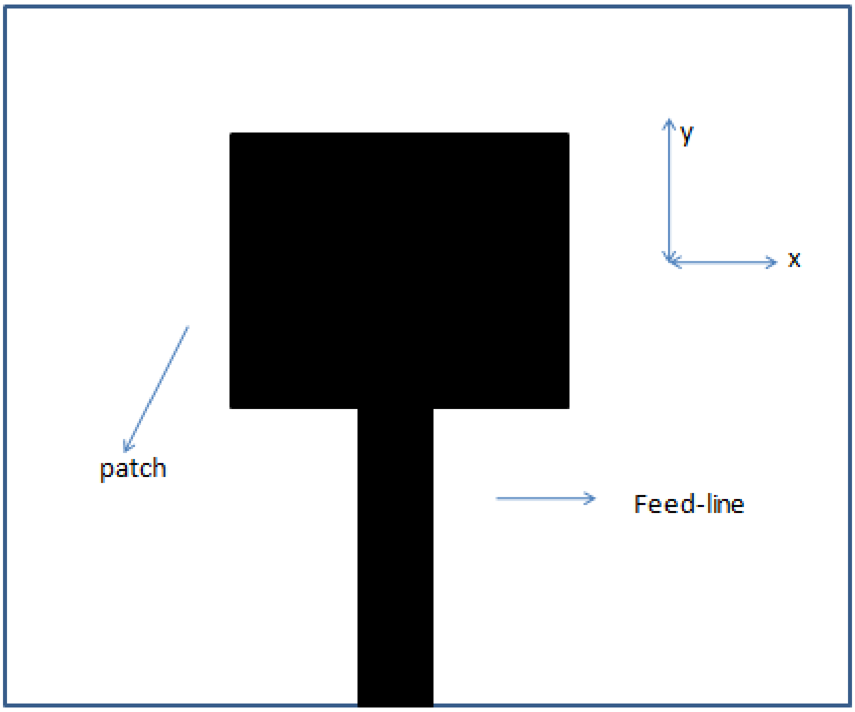

Fig 3.1 Rectangular microstrip patch antenna [3]

3.2 CHARACTERISTICS OF MICROSTRIP PATCH ANTENNA

It received attention in the beginning of 1970, when the idea can be traced and its patent comes into picture. It is comprised of a very thin metallic patch above a grounded dielectric substrate. The dielectric material is placed between the patch and the ground plane. It is designed to achieve maximum radiation which is normal to patch. There are different varieties of substrates which are used to design the microstrip antenna. Thin substrates which contain higher value of dielectric constant are desirable for the design of microstrip antenna. They are often called as patch antenna and patch may take the shape of square, rectangle, circular, triangular and elliptical configuration. Microstrip dipoles are attractive in nature as they possess a wider bandwidth and occupy minimum space requirement. Single element or array of microstrip antenna element is needed to achieve linear and circular polarization. Greater directivity is achieved by using one or more elements of patch antenna with the design of single or multiple feeds.

3.3 ADVANTAGES

Its manufacturing cost is less due to its 2-dimensional geometry. Workings of these antennas are done at extremely high frequency as its size is directly connected to the wavelength of the antenna. The maximum directive gain of approximately 6-9dBi is achieved by a patch antenna with single feed-line characteristics .They have a high gain in a low-profile antenna due to which they are used in airplanes and in other military applications. Microstrip patch antennas are low in profile, economical, low in cost antennas which is easily attached to all the rigid surfaces. These antennas are a useful part of microwave design and their frequencies. They can be fabricated by the help of photolithographic techniques. Due to their light weight and low manufacturing cost they are attractive in nature. The polarization diversity is one of the advantages possessed by patch antennas. Patch antennas have all types of polarization whether vertical, horizontal, right hand or left hand circular by the use of single or multiple feed-line characteristics.

3.4 DISADVANTAGES

Major disadvantages includes are the poor efficiency of patch antenna, minimum power, high quality factor (in terms of 100), indifferent polarization, very narrow bandwidth , performance is of low quality ,feed radiation is also spurious one. They also have a low impedance bandwidth. Sometimes the greater ohmic loss occurs in the feed-line of the patch antenna. The power handling capacity of this antenna is also low. If we want high performance array antenna so for this we need high complex structures. Sometimes the height of a substrate is increased which introduces surface waves in it and it is not desirable for the patch antenna as the power is taken out from the total available power for the feed radiation. The antenna performance and polarization characteristics get degraded when the patch is placed between the dielectric substrate and it gets fixed at the bends and discontinuity.

3.5 APPLICATIONS

Microstrip antenna has a variety of applications like

1) In satellite communication

2) In remote sensing and environmental instrumentation

3) In mobile radio (telephone, pagers)

4) Satellite navigation receivers

5) In control systems

6) In various bands like c-band, x-band etc

3.6 FEEDING TECHNIQUES

It is one of the important parameter as input impedance and characteristics of an antenna depend on it. Microstrip antenna is excited by various feeding techniques like:

1) Aperture coupled feed: In this technique, the field is coupled from the microstrip feed-line to the radiating patch element or a slot in the ground plane. The amount of coupling determines the size, shape and location of aperture.

Disadvantage: It has low or poor bandwidth and it is not easy to fabricate.

2) Microstrip line feed: It is the simplest feeding technique in which the feed is conducting and connected to the patch element. The width of the feed must not be greater than the patch element.

Advantage: Planar structure is obtained as the feed-line can be fixed on the same substrate.

Disadvantage: With the increase in the thickness of the substrate layer the false feed radiation also gets increased.

3) Coaxial feed: In this feeding method, the inner connector of coaxial connector draws out through a dielectric material while the ground structure is connected with the outer connector.

Advantage: For the exactly matching of input impedance feed-line is placed at any desired location inside the patch and feed radiation is somewhat genuine.

Disadvantage: It has poor bandwidth and it is difficult to construct for thick substrates. The formulae of length and width of antenna can be calculated by the given design equations.

3.7 DESIGN EQUATIONS FOR MICROSTRIP PATCH ANTENNA [3]

A To calculate the patch width

$$w = \frac{c}{2f_r\sqrt{\frac{\varepsilon r+1}{2}}} \qquad - (1)$$

Where w= patch width

f_r =resonant frequency

c= velocity of light

B To calculate the patch antenna length

$$L = L_{eff} - 2\Delta L \qquad - (2)$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\in_{eff}}} \qquad - (3)$$

Where $\in_{eff}$ can be calculated by

$$\in_{eff}= \frac{\in_r+1}{2} + \frac{\in_r-1}{2}(1 + 12h/w)^{1/2} \qquad - (4)$$

And $\in_{eff}$ is defined as the effective dielectric constant

CHPTER-IV

4.1 INTRODUCTION TO ULTRA WIDE BAND ANTENNA

The federal communication commission (FCC) allocates the ISM (Inter Scientific and Medicine bands) for unlicensed communication use in the middle of 1980s. The FCC has allocated a bandwidth of 7.5 GHz from 3.1 GHz to 10.6 GHz for the various applications of Ultra-wide band in 2002. According to the rules and regulations of FCC any signal which occupies at least bandwidth spectrum of 500 MHz can be used in UWB systems. From this it can be said that ultra-wide band communication is not restricted to impulse radio only but it is applied to any technology which uses 500 MHz spectrum and meet all other requirements of ultra-wide band communication.

4.2 ADVANTAGES

There are many advantages of ultra wide band antenna:

1) According to Shannon capacity theorem channel capacity is proportional to bandwidth of an antenna. Since ultra wide band has a wide frequency bandwidth so it will achieve capacity in the range of megabits per second or Giga bits per second with distance of 1 to 10 metres.

2) These antennas operate at low power transmission lines. If the power of signal is divided across a high frequency range the given frequency range is not affected by the noise.

3) Ultra wide band provides high secure and reliable communication as interference only occurs in some part of the spectrum. So it is the most secure means of wireless transmission.

4) Cost and complexity of ultra-wide band antenna is low as it is related to impulse radio features.

4.3 APPLICATIONS OF ULTRA-WIDE BAND SYSTEMS

1) Firstly UWB provides high data rates by using very less power which makes it useful for wireless personal area networks (WPAN) applications.

2) In limited range the high data rate characteristic makes it suitable for indoor location with a much higher degree of accuracy. We can also determine precise location of moving objects in indoor communication within an accurate range of centimetres.

3) UWB systems can work in complex environment and can be used in situations like casualties in building collapsed after an earthquake and finding injured tourists in remote area.

4) It is also applicable to radar and imaging applications and can be used in military purposes to locate the position of enemy objects behind the wall and around the corners in a battle field.

4.4 INTRODUCTION TO DEFECTED GROUND STRUCTURE

There are several techniques which are applied to microwave circuits in which the ground plane of a patch antenna is modified to enhance the parameters of an antenna called defected ground structure. It is basically a defect in the ground layer which is taken as an approximation of an infinitely dielectric material. The defect is added in the ground plane to minimize the dimensions of an antenna for a resonant frequency as compared to antenna which is without defects in the ground plane. Realization of defected ground structure takes place by adding a defect in the ground layer which will disturb the distribution of current and it depends upon the shape of defected ground structure. When the distribution of current is disturbed it will also influence its input impedance and flow of the current. It can also handle the propagation of electrical and magnetic waves which passes through the layer of substrate. Without defected ground structure microstrip antenna has narrow bandwidth and high return loss parameter. But the antenna with the defects in the ground structure provides high operating bandwidth and less return loss. We do not need additional circuits for the DGS implementation but it can be integrated onto ground plane to improve its radiation.

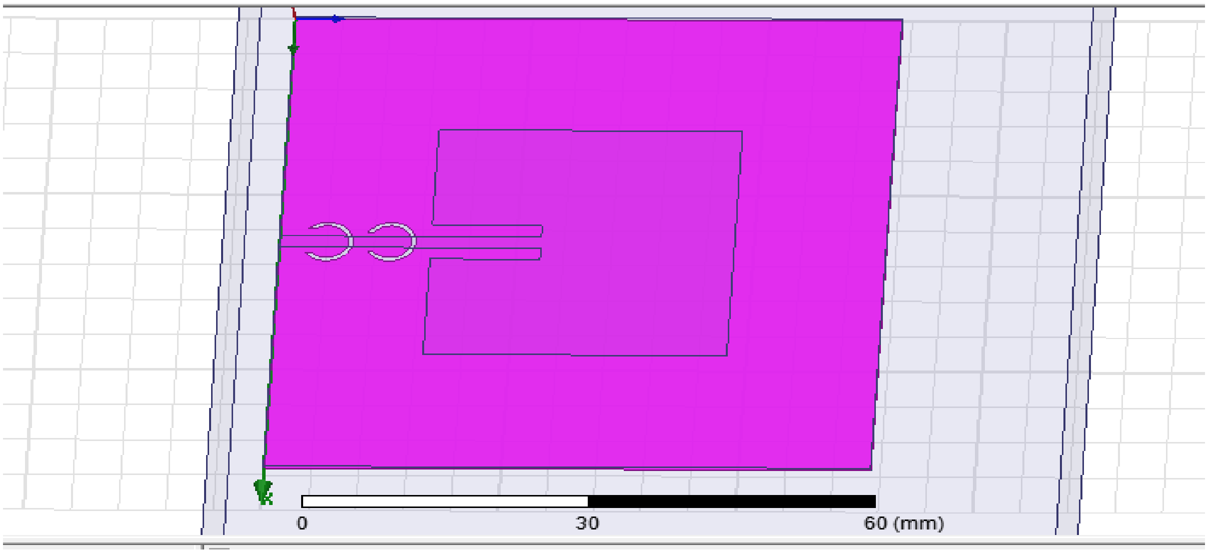

Fig 4.1 Partial ring shaped defected ground structure [27]

4.5 ADVANTAGES

1) DGS will improve the harmonics in the ground plane.

2) It will reduce the size of an antenna.

3) It will improve the return loss parameter.

4) It will also improve the gain and bandwidth of an antenna.

CHAPTER-V

LITERATURE REVIEW

Kumar et.al [2005] worked on A-shaped defected ground structure which showed asymmetry in a specific radiating plane of microstrip element. Defects having different orientations with respect to different aspect ratio of patches has been studied here. The isolation between co-polarized and cross-polarized has been achieved over 190 degree angular range which is 140 degree more than the conventional ground plane characteristics. In this design there is a significant improvement in the cross-polarization characteristics of a rectangular shaped or square shaped patch.

Aris et.al [2008] presented a microstrip array antenna which is reconfigurable and used Dumbbell shaped as the shape of defected ground structure and its characteristics gives us two resonant frequencies 7.5 GHz and 8.85GHz. The characteristics of above antenna are based on changing modes of the switches on the feed-line. If the switch is in "Open'' mode, the antenna gives us a resonant frequency of 7.5GHz and when the switch is in "Short" mode gives us a resonant frequency of 8.85 GHz. This antenna improves the parameters like directivity so it is used for wireless outdoor applications.

Pei et.al [2011] proposed triple band antenna with defects in the ground structure for the purpose of WLAN and WIMAX applications. The microstrip antenna contains circular shaped ring, Y-shape strip and by the introduction of Y-shape strip in the circular ring the antenna resonates at dual frequencies. The given antenna covers all the 2.4/5.2/5.8- GHz operating bands of WLAN and WIMAX .With the introduction of arc shaped ground plane with an isosceles triangle defect the triple wide band characteristics is obtained with the achievement of good impedance matching condition . The gain of above antenna reaches up to 2.57 dBi. This antenna has several characteristics such as small in size, good radiation pattern as well as excellent return-loss characteristics.

Kandwal et.al [2013] proposed a novel design of a circular patch with a Z-shape defected ground structure for microstrip patch antenna to enhance the bandwidth. A wideband is obtained in the frequency range of 8 GHz -12GHz so it is applicable for X-band applications. The peak gain obtained is 8.7dBi by achieving impedance bandwidth of 1.2 GHz respectively. The return-loss, bandwidth, gain and VSWR are measured experimentally and then compared with the simulated results.

Biswas et.al [2013] proposed microstrip patch antenna with a microstrip line feed with an open ended stub and its ground element is taken in the form of partial ring shaped defected ground structure. By using defects in the ground plane control and rejection of third order harmonics is there .To improve rejection characteristics open ended stub is added to feed line. The area occupied by proposed defected ground structure has been reduced by 40% to 90% as compared with the other designs. The proposed antenna finds applicable for microwave integrated circuit design where only single substrate layer is required.

Kumar et.al [2014] presented a microstrip array antenna with integrated defects in the ground structure to improve the polarization. A defected ground structure has been designed in X-band which is showing the improving nature of co-polarized to cross-polarized radiation pattern. By using only one DGS structure between two array elements minimizes the inter-element spacing. It demands no additional space and cost so this antenna is used in industrial applications.

Kumar et.al [2015] proposed a circularly polarized antenna which has a dual wide band and consists of a circular patch and defected ground structure. To achieve circular polarization, coaxial probe feed 45 degree with the stub plane is used. The ground structure is also defected and two circular slots are etched from the ground plane. We can see the increase in bandwidth by using defected ground structure. The good return loss and gain shows that the designed antenna is applicable for various applications like C-band and X-band radar and satellite communication.

Ghosh et.al [2015] proposed a simple rectangular microstrip patch antenna in the ground structure as dumbbell shaped design which is used for suppression of cross polarization without affecting the radiation pattern. It has an excellent radiation pattern with wide elevation angle for different width to length ratio of proposed antenna. It is very much effective where good polarisation purity is required and for wide coverage applications.

Kunwar et.al [2015] presented an antenna with inverted L-slot and defects in the ground structure for the purpose of applications like WLAN and WIMAX. The given antenna resonates at triple band which is starting from 2.39-2.51 GHz, second from 3.15-3.91 GHz and third from 4.91-6.08 GHz respectively. The antenna covers the complete WLAN band (2.4/5.2/5.8 GHz) and WIMAX band (2.5/3.5/5.5GHz). Therefore the given antenna combines the features of above the dual bands in a single device by achieving good radiation pattern. It has a compact size of $20x30mm^2$ as compared to other designs. The radiation pattern obtained is Omni-directional pattern and it has better impedance matching condition.

Shari et.al [2015] presented the rectangular microstrip antenna which shows different effects on the defected ground plane. To see the performance of antenna the ground structure is modified by adding a slot in the form of aeroplane shaped defected structure. It is suitable for

WLAN wireless local area network which works at 2.4 GHz frequency. The results show that 65% reduction in size as compared to antenna without defected ground structure.

Luo et.al [2015] presented an ultra wide band multiple input multiple output antenna which contains two slot antennas and a ground plane with T-shaped slot in it. This antenna improves the impedance matching condition in the low-frequency range and mutual coupling is reduced for frequencies greater than 4GHz. It will also reduce the problem of multi-path propagation in wide band antennas.

Kunturkar et.al [2015] presented a monopole antenna as a fork-shaped antenna which is suitable for wireless devices. It contains a patch as a fork shaped and a T-slot in ground plane .The antenna with defected ground structure shows better results as compared to antenna without defected ground structure. This antenna works on different resonant frequencies like 1.21-1.29GHz, 5-5.20GHz respectively. Because of resonating at different frequencies it can suitable for WLAN and wireless applications.

Troung et.al [2015] presented a compact design to upgrade the bandwidth of a rectangular microstrip patch antenna. The ground element is chosen to be defected ground structure. The feeding technique used is microstrip line. The results of measurement and simulation show that antenna has a good return- loss and an upgraded bandwidth. The performance of an antenna with defected ground structure is analyzed through HFSS via a finite element.

Kundu et.al [2016] proposed the design of a microstrip antenna for the application of WIMAX. It consists of a rectangular patch with only one layer of coaxial feed-line. The maximum gain of 2.15 dBi is attained at 3.5GHz resonant frequency. Simulation results of proposed antenna indicate that VSWR obtained is 1.000374 close to the center frequency i.e. (3.5 GHz). The measured bandwidth (3.295 GHz-3.645 GHz) and simulated bandwidth (3.36 GHz-3.715 GHz) of the patch antenna exceeds 10% below the range of VSWR as two. The given antenna has achieved better impedance matching and also obtained good radiation pattern in the complete frequency range of WIMAX application.

Rameswarudu et.al [2016] proposed different methods to design a compact microstrip patch antenna which has step slots on the ground plane and square ring slots on the patch element. It is designed for ultra-wide band applications as it has wide bandwidth and good return- loss. The proposed antenna has a resonant frequency of 18 GHz to 20 GHz. It also shows good radiation behaviour within the frequency spectrum of ultra-wide band antenna. This given antenna is suitable for K and Ka band applications like in satellite and radar applications.

Rameswarudu et.al [2016] proposed an antenna for dual band applications which consists of microstrip antenna with defects in the ground structure. The square shape of patch with a 3-shaped slot and a ground plane with tapered step and it shows good characteristics in wireless communication with increase in gain, bandwidth and directivity. The dimensions of an antenna are 12mm×18mm×1.6mm printed on FR-4 substrate. This antenna finds its application in microwave applications due to enhanced bandwidth and gain.

Subramanyam et.al [2016] proposed a defected ground structure as modified spiral-shaped (M-DGS) structure fixed on a coplanar waveguide. To achieve exactly true band stop performance, inner spiral turns from the earlier design is getting removed. Each inner spiral turn gives its contribution to harmonics and resonant frequency is controlled by outermost spiral turns. No other harmonics is obtained up to 10 GHz frequency range. Both the conventional shaped and modified shaped defected ground structure is single layer planar structures. They consist of coplanar waveguide transmission line and defected ground structure on both the ground planes.

Acharjee et.al [2016] proposed an antenna which controls the greater order harmonics up to fourth order harmonic of the basic frequency. Patch element is taken as a rectangular shaped with an inset cut on microstrip feed line. For rejection of complete harmonics, defected ground structure is taken the shape of I -shape and it is used below the feed line. By introducing one L-shaped inverted stub, the rejection characteristics are improved further. This above antenna has its demand in microwave integrated circuit design.

Mondal et.al [2016] proposed microstrip patch antenna with a modified ground pane to enhance gain and bandwidth parameter of an antenna. The shape of ground plane is square and circular with a radiating patch of W-shape and V-shape design. Further the shape of ground plane is modified by adding A U-shaped slot in it. The proposed antenna is suitable for IEEE 802.11a (5.15-5.35 GHz), WLAN band (5.15-5.85 GHz), C-band (4 GHz-8 GHz) and X-band (8 GHz-12 GHz) respectively. The maximum peak gain obtained is 5.1 dBi. The frequency band covers from 3.04 GHz to 10.01 GHz with a percentage bandwidth of 106.8%. The antenna finds its applications in modern wireless communication where small size antenna is preferred. The measured and simulated results have been compared with vector network analyzer.

Wei et.al [2016] proposed a periodic defected ground structure an S-shaped which is used for reduction of mutual coupling between the elements of an antenna structure. The PDGS contains 3 S-shaped DGS embedded between the elements of an antenna. More than 40 dB mutual coupling is getting reduced by using this proposed design of antenna structure. Both the parameters of an antenna and PDGS related units are required to perform in the same condition.

Biswas et.al [2016] proposed a microstrip antenna which was radiating at different frequencies and suppression of harmonics up to third harmonics is taken into consideration. Without affecting fundamental frequency the design will reduce higher order harmonics. Low pass filter with defected ground structure as dumbbell shaped structure is constructed. Stop band of Low pass filter is used to reject the higher order harmonics whereas fundamental frequency is passed through pass band. This antenna has been applicable to wireless local area network.

CHAPTER VI

SCOPE OF STUDY

Ultra wide band antenna is preferred due to its various attributes like simple in design, impedance bandwidth and Omni-directional radiation pattern. The simplest way to construct all these antennas is by using microstrip feeding technique. Defected ground structure is one of the techniques which are used to implement the patch antenna. DGS structure is obtained by adding defects in the ground plane which will affect the distribution of current which depends on the size and shape of defect. The distribution of current will also affects the input impedance and the flow of current of the antenna. DGS structure can also restrain the propagation of electromagnetic waves and the excitation through the dielectric substrate of the antenna. It improves the return-loss parameter and also enhanced the gain and bandwidth of an antenna. Various shapes of defected ground structure are possible like I-shaped DGS, dumb-bell shaped DGS, partial ring shaped DGS etc. But the two symmetrical U-shaped DGS has been used to broaden the impedance bandwidth of a microstrip-fed antenna. The design contains U-shaped defects in the ground on one side of substrate and Y-shape patch is on the other side of substrate. The implementation of complete design is done by using Ansoft HFSS v13.0. All the antenna parameters can be calculated by the above mentioned software. Moreover the given design has achieved Omni-directional radiation pattern which is required for ultra wide-band antenna. It is suitable for various applications like WIMAX, WLAN, satellite and X-band.

CHAPTER VII

OBJECTIVE OF STUDY

1) To increase the impedance bandwidth of the antenna by using defects in the ground plane.

2) To improve return loss parameter by changing the feed-line characteristics and the shape of patch.

3) To enhance the gain parameter of the antenna.

4) By the use of defected ground structure we come to know about the current distribution of the design that implies which region contains highest density of current.

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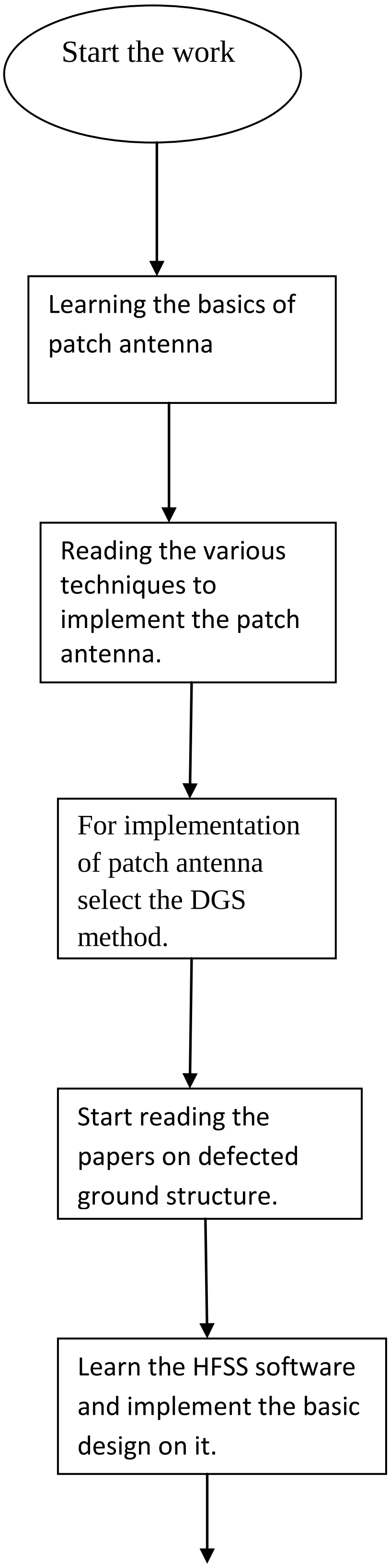
CHAPTER VIII

RESEARCH METHODOLOGY



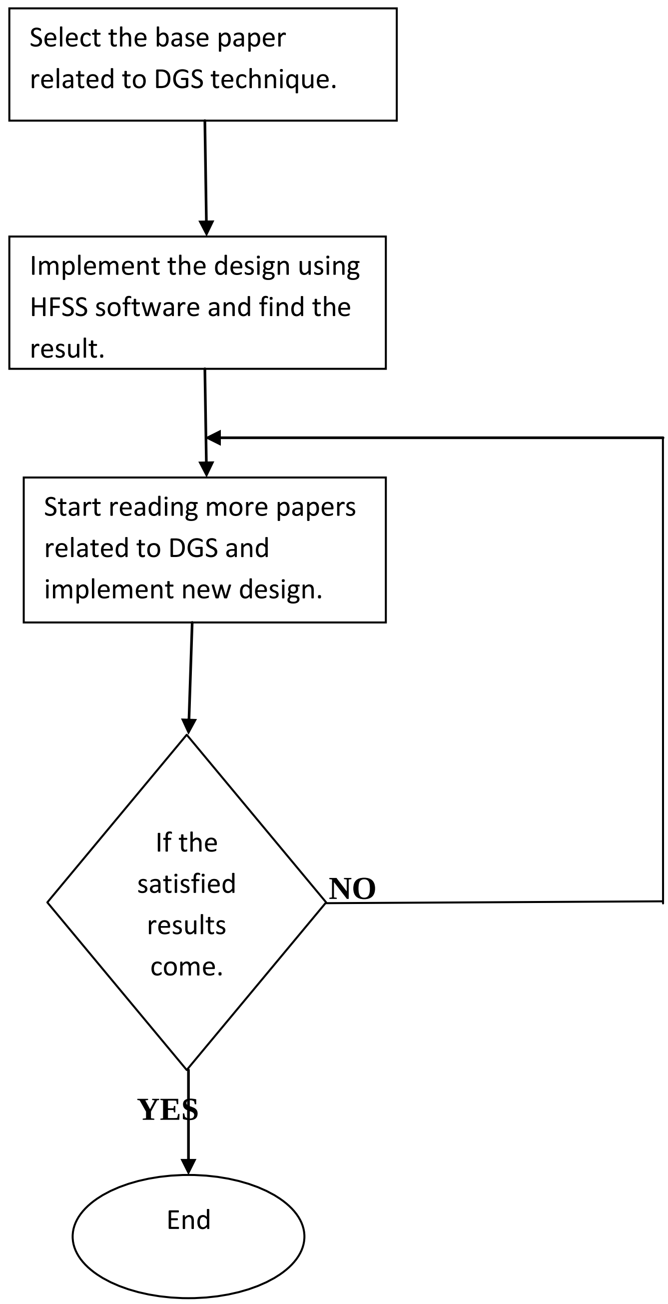


Fig.8.1 Process design for antenna

CHAPTER IX

BASE PAPER IMPLEMENTATION

9.1 DESIGN SIMULATIONS

First design is to make patch antenna with microstrip line feed and we get harmonics in it. So we use partial ring shaped defected ground structure to remove and reject the harmonics. And then stub is added in the feed-line to enhance the stop band characteristics.

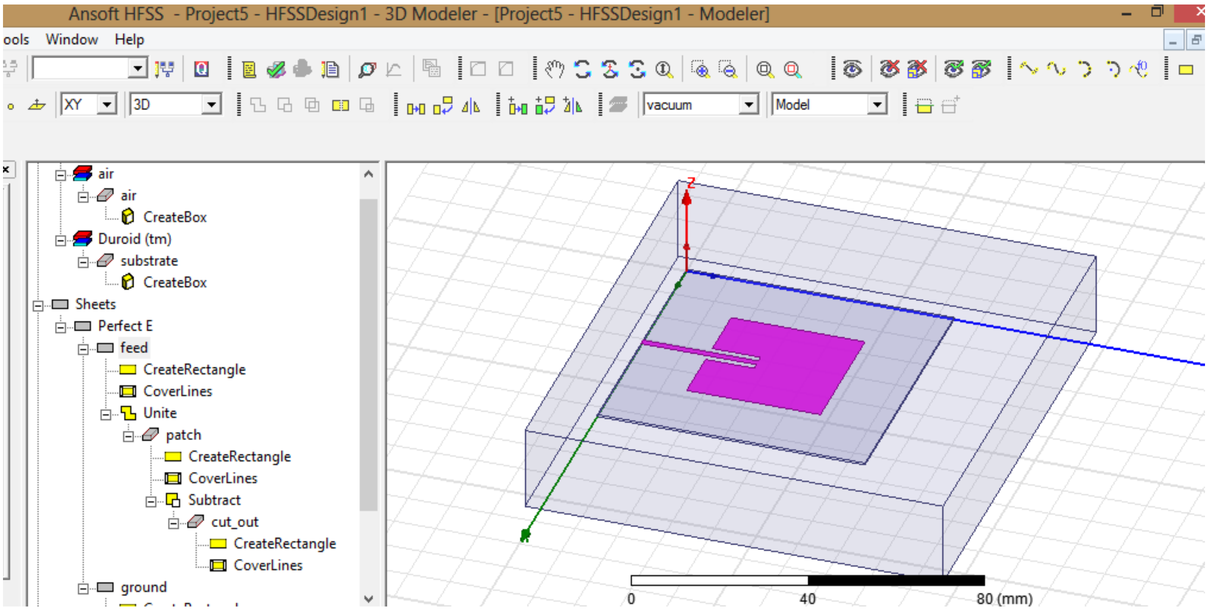


Fig 9.1 Patch antenna using microstrip line feed

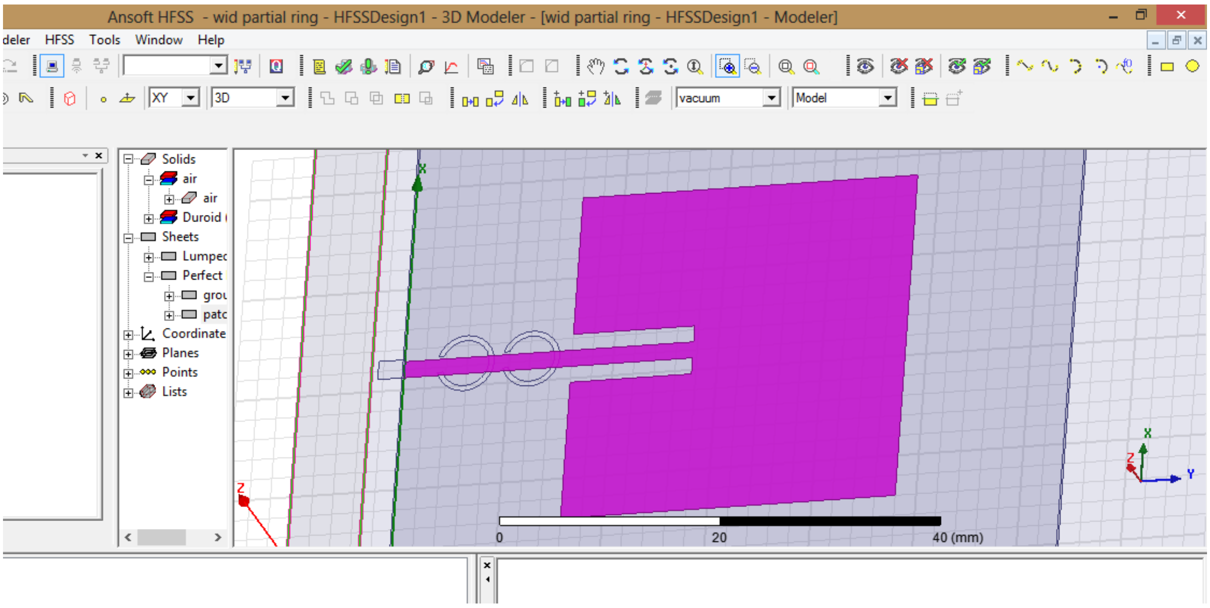


Fig 9.2 Partial ring defected ground structure

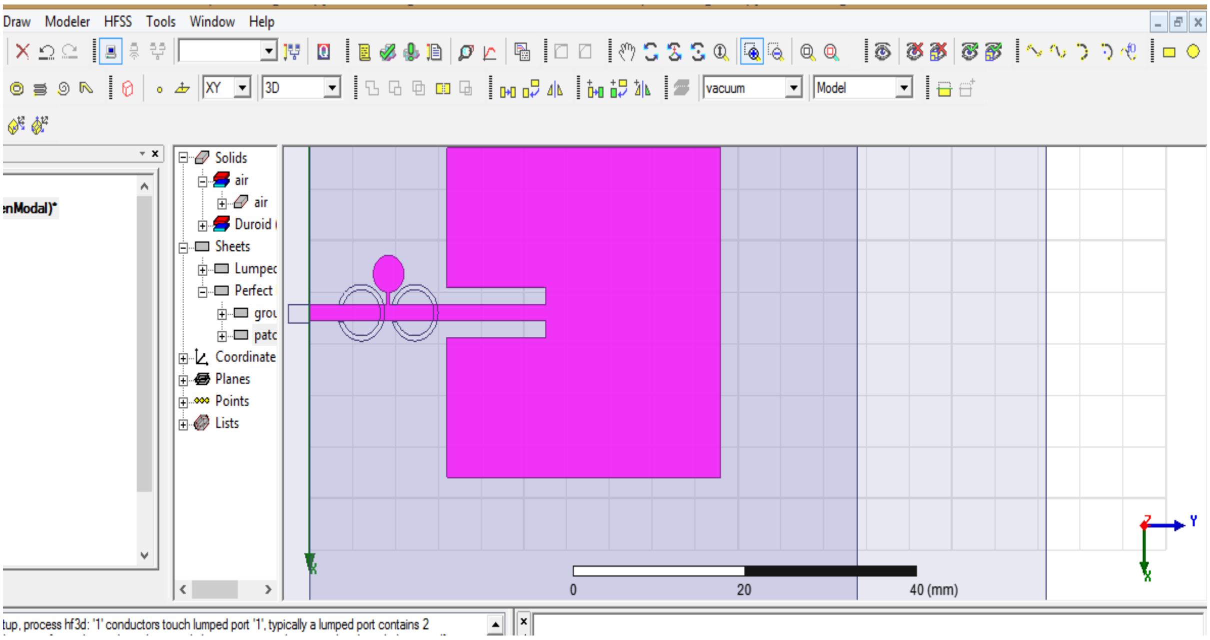


Fig 9.3 Adding a slot in the feed line

After making the complete design we get return–loss characteristics of microstrip fed antenna. The figure shows that the return-loss contains a lot of first order, second order and third order harmonics and along with it some other frequency parameters.

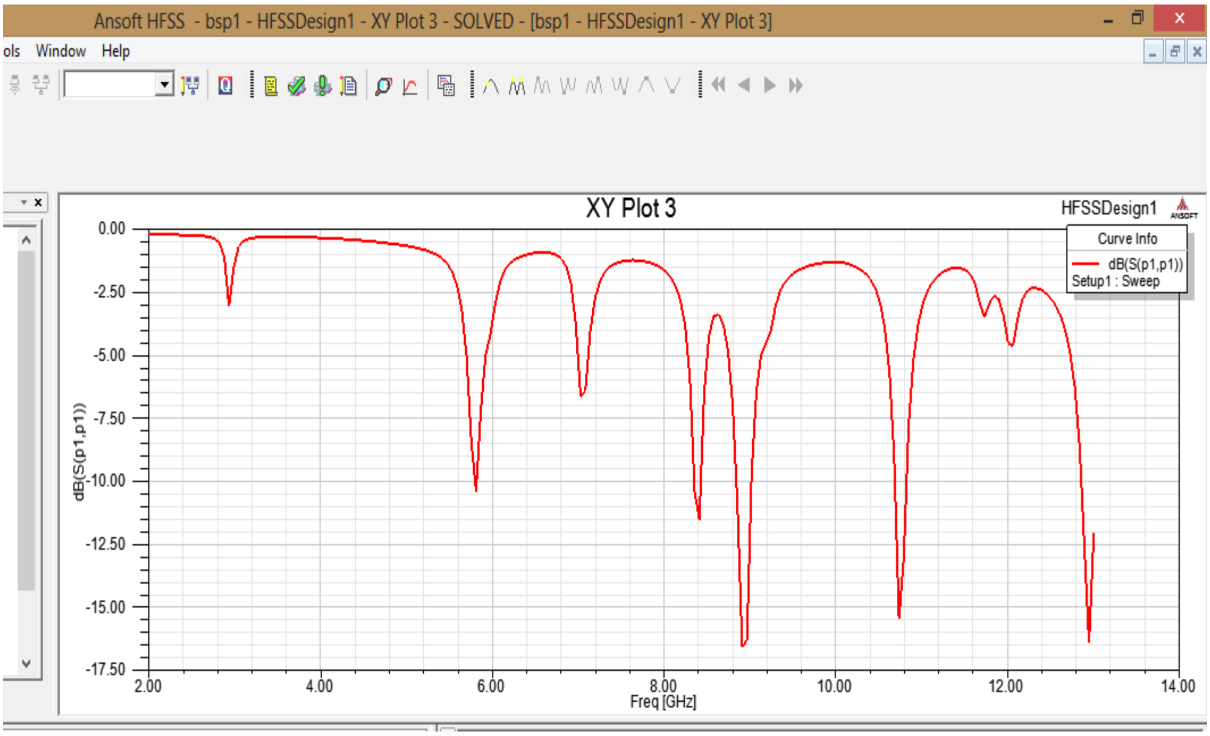


Fig 9.4 Return-loss parameter with microstrip-feed design

The table given below shows the harmonics and their return-loss characteristics and these are removed by adding defects in the ground plane.

Table 9.1 Table showing various harmonics

FREQUENCY (in GHz)	RETURN LOSS (in dB)
2.9648	-2.90
5.7930	-10.17
7.0352	-6.48
8.3833	-11.07
8.8987	-16.32
10.6696	-14.70
12.9295	-16.15

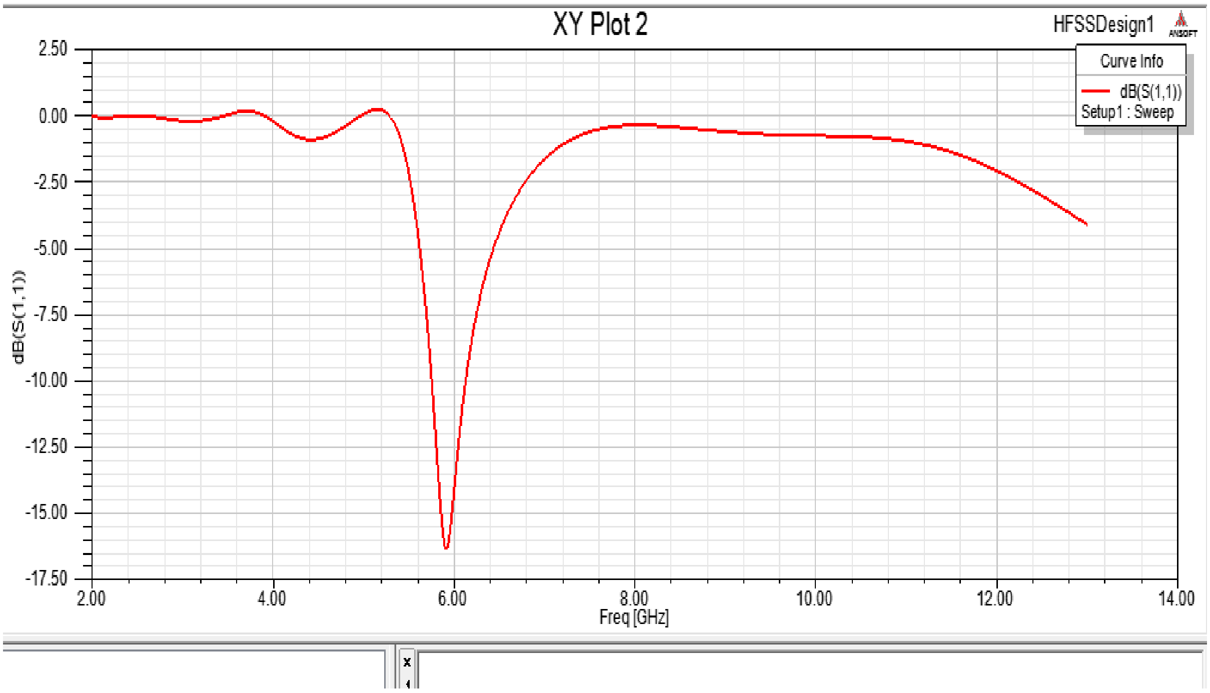


Fig 9.5 Return loss parameter with defected ground structure

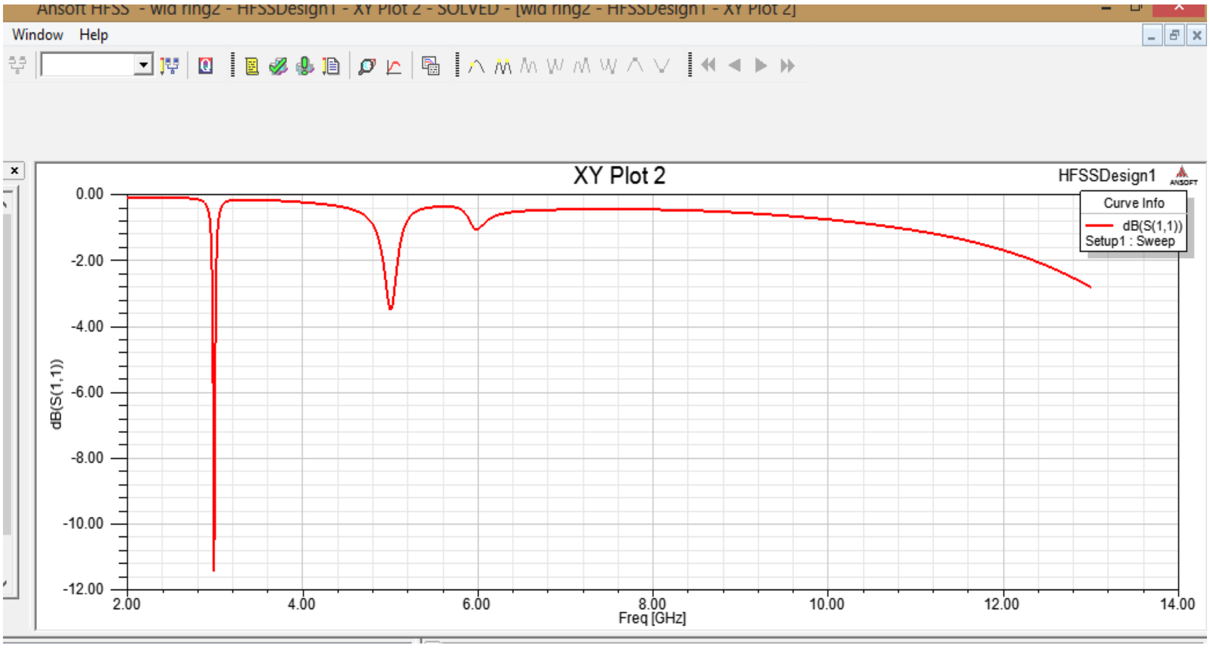


Fig 9.6 DGS-integrated feed line

Another design which was implemented by me on HFSS software is probe feed antenna and its return-loss characteristics. The given antenna resonates at 2.25 GHz frequency range.

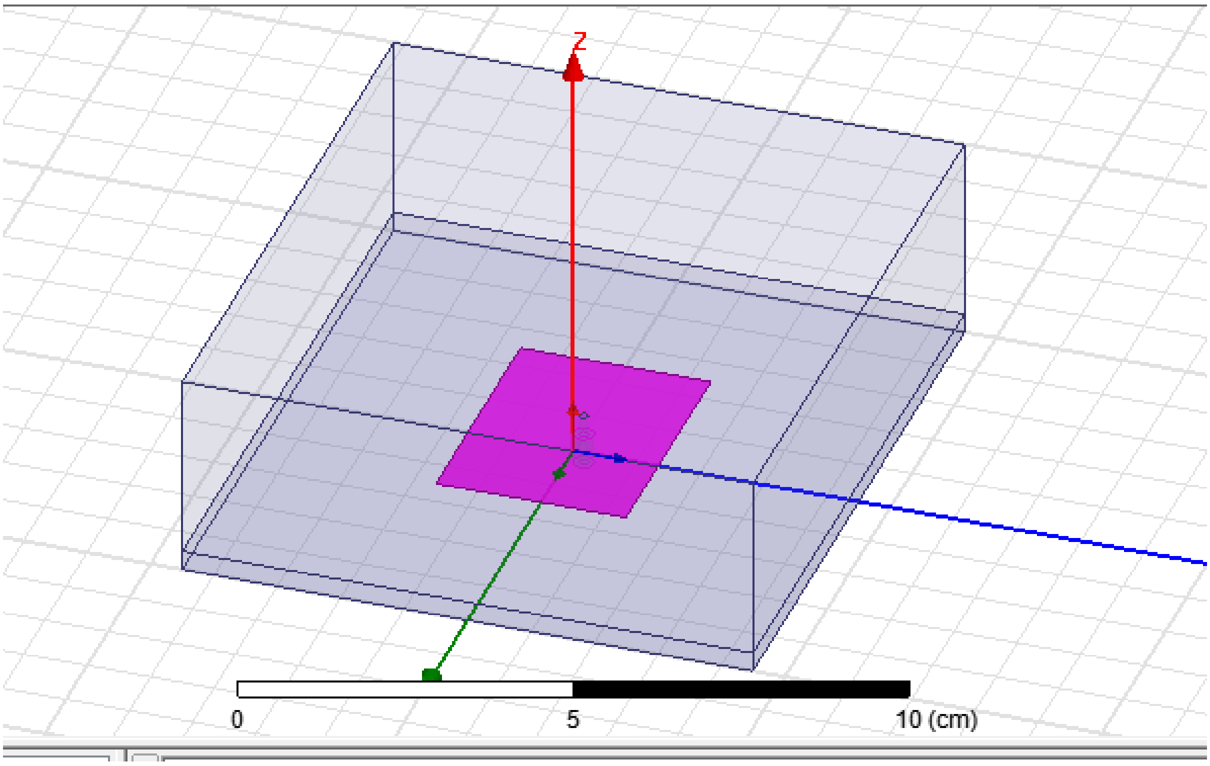


Fig 9.7 Probe feed patch antenna

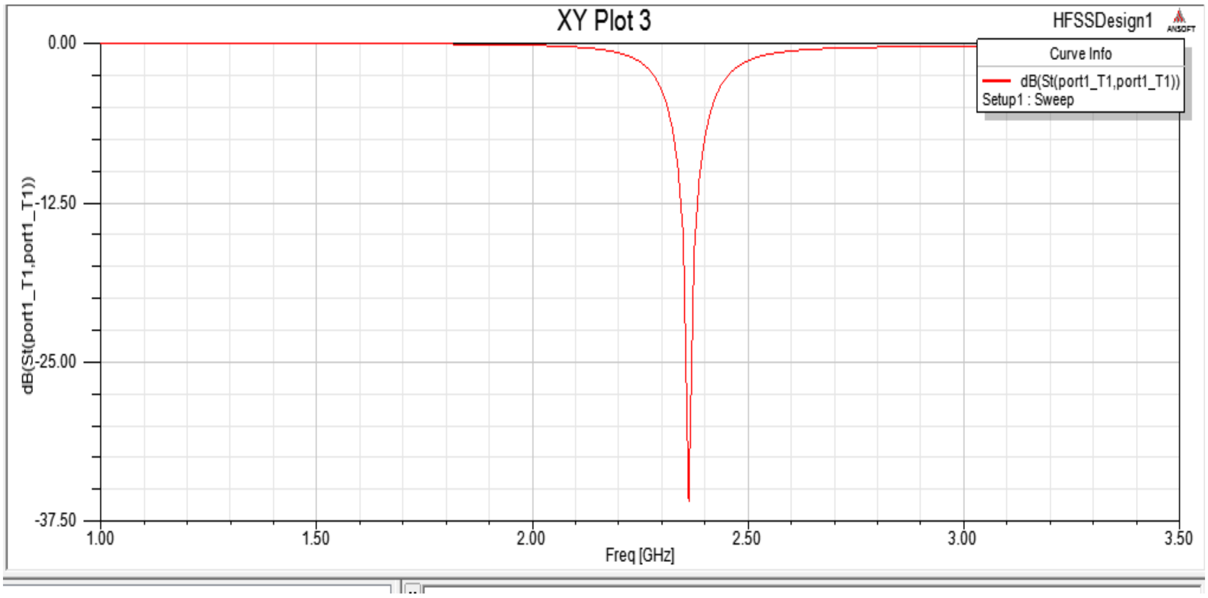


Fig 9.8 Return loss characteristics

CHAPTER X

PROPOSED DESIGN AND ITS IMPLEMENTATIONS

10.1 DESIGN IMPLEMENTATIONS

A U-shaped novel antenna is designed with Y-shaped patch and defected ground plane.

Step 1-The substrate used is RT-DUROID with a thickness of 1.57mm. The design is implemented by HFSS software.

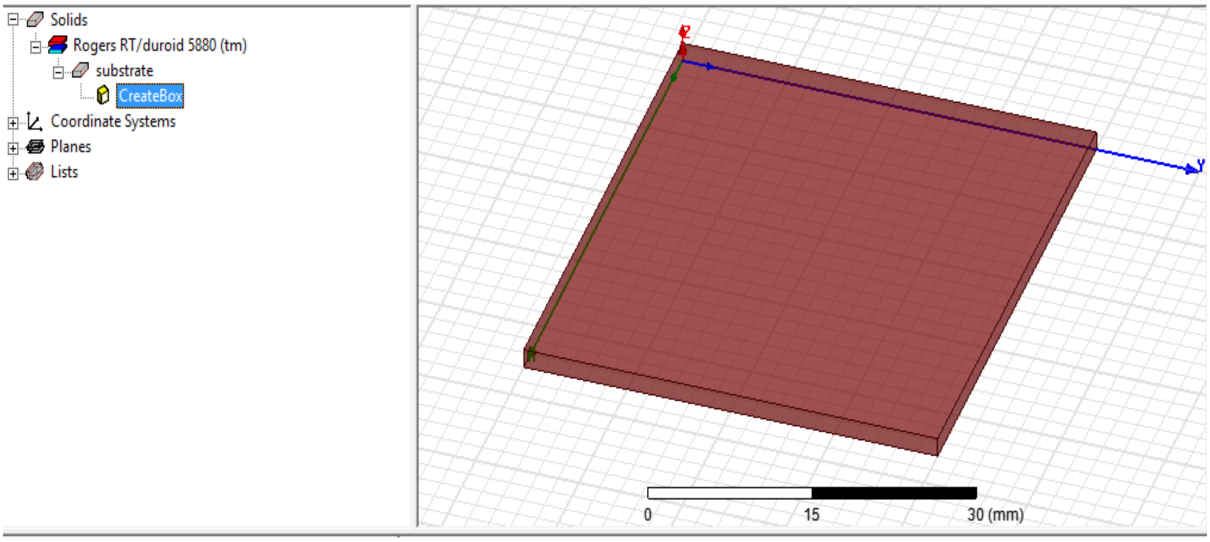


Fig 10.1 Substrate as RT-DUROID material

The dimensions of the substrate are 46mm, 40mm and 1.57mm respectively.

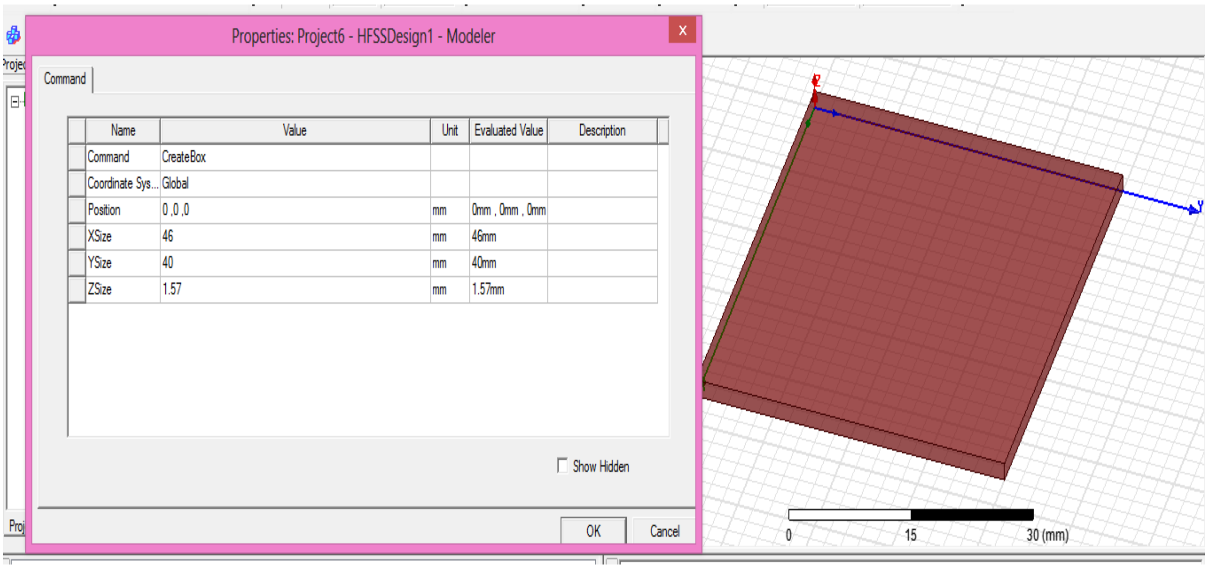


Fig 10.2 Dimensions of the substrate

Step 2- Then design of ground plane is there which has dimensions of 23mm and 40 mm respectively. Assign perfect-E boundary to the ground plane.

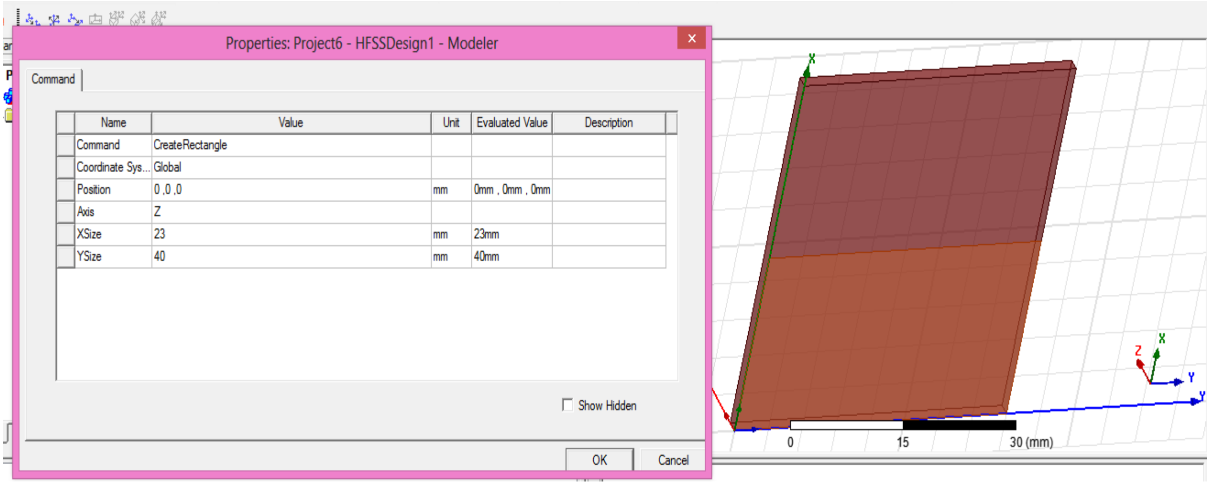


Fig 10.3 Ground plane

Step 3- Now in ground plane we draw two symmetrical U-shaped defects and then subtract them from the ground plane. First draw bigger slot names as slot 1 and then subtract it from slot2 so that one U-shaped defect. The dimensions of the bugger slot are 18mm and 15mm.

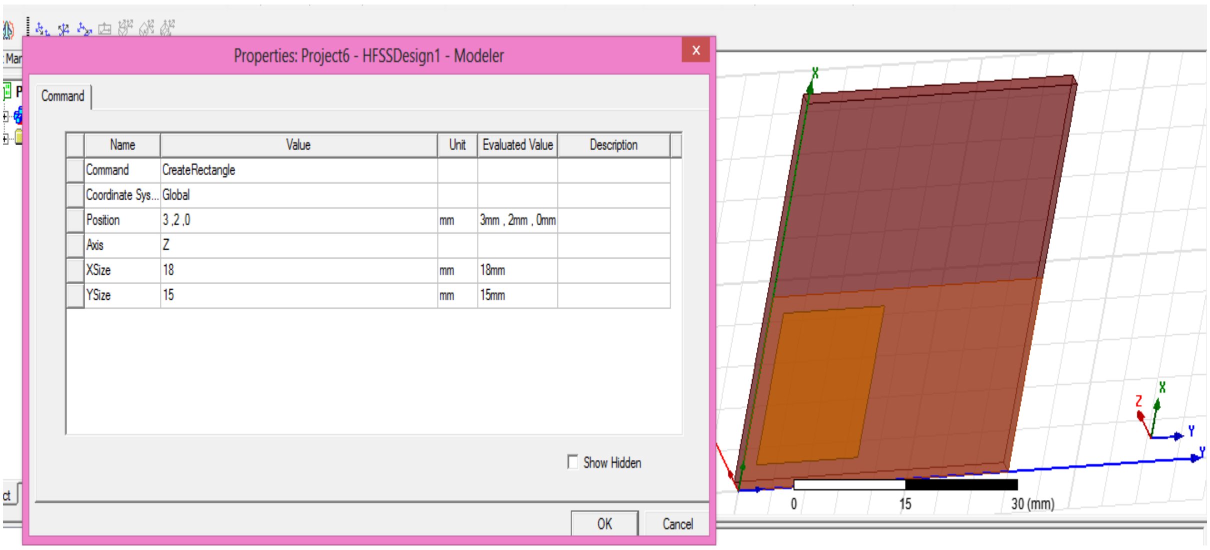


Fig 10.4 Bigger slot in the ground plane

Step 4- Now make smaller slot which has dimensions of 15 mm and 5 mm respectively and subtract bigger slot from the smaller one and we get U- shaped defect in the ground plane.

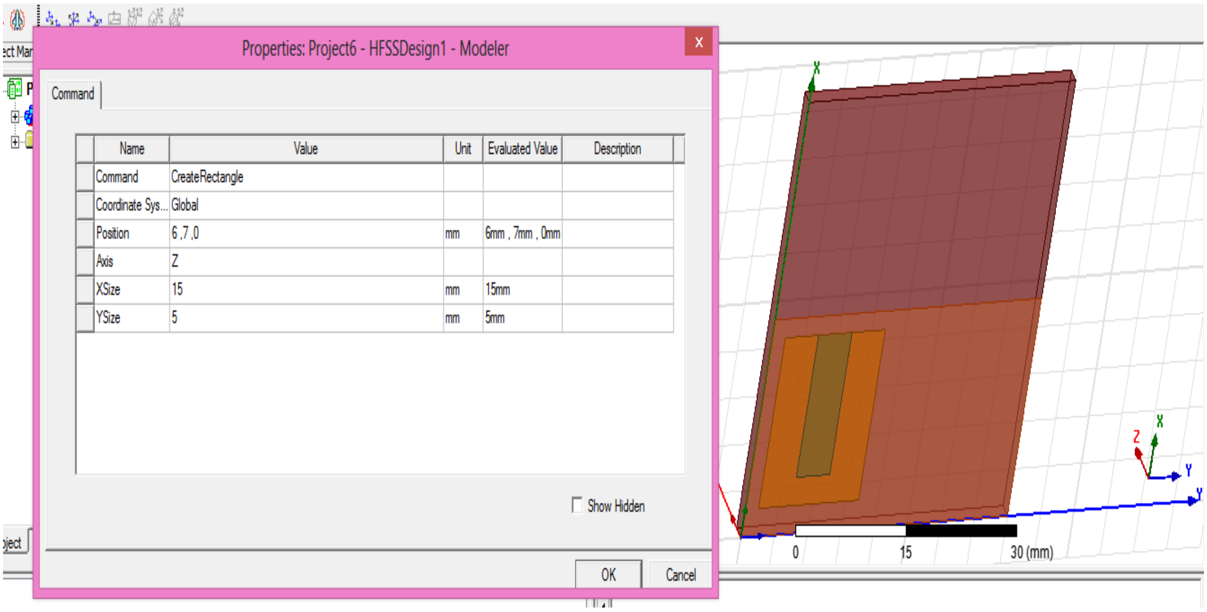


Fig 10.5 Smaller slot in the ground plane

After subtraction of bigger slot from smaller one we get u-shaped defect in the ground plane and construction of ground plane takes place in X –Y direction.

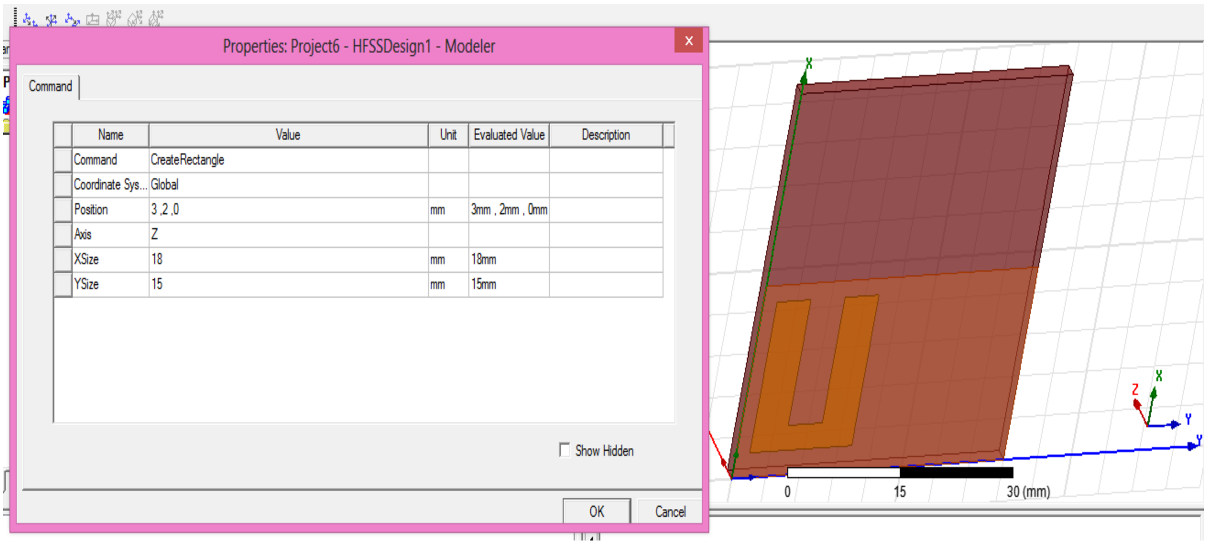


Fig 10.6 A U-shaped defect

Step 5- Likewise make another bigger and smaller slot and subtract bigger one from smaller one so that we get two symmetrical U- shaped defects in the ground structure. The length and width of slot3 and slot 4 are same as slot 1 and sot 2 only the position of x and y are different.

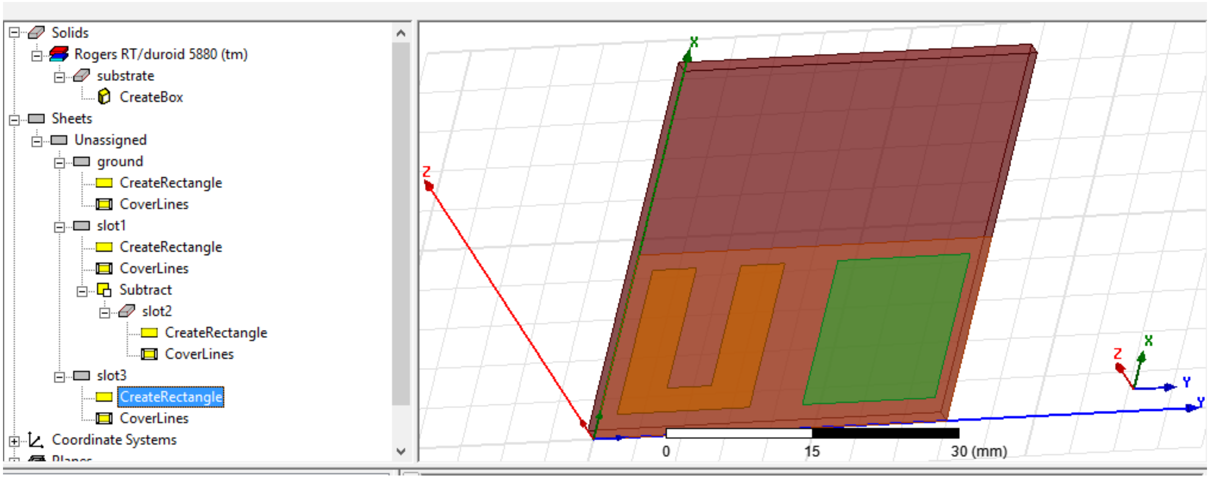


Fig 10.7 Another bigger slot in the ground plane

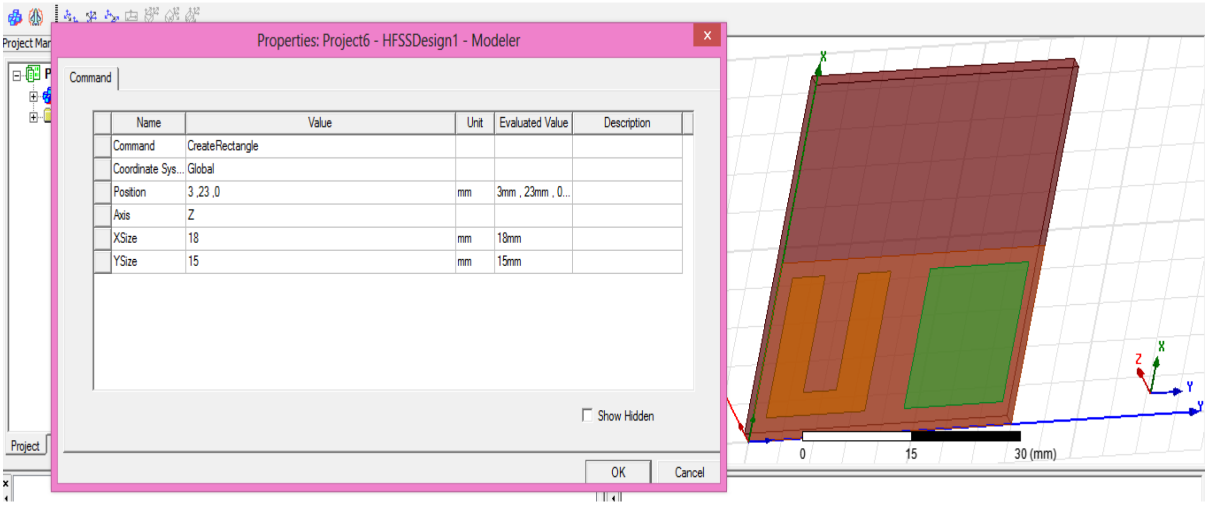


Fig 10.8 Dimensions of another bigger slot

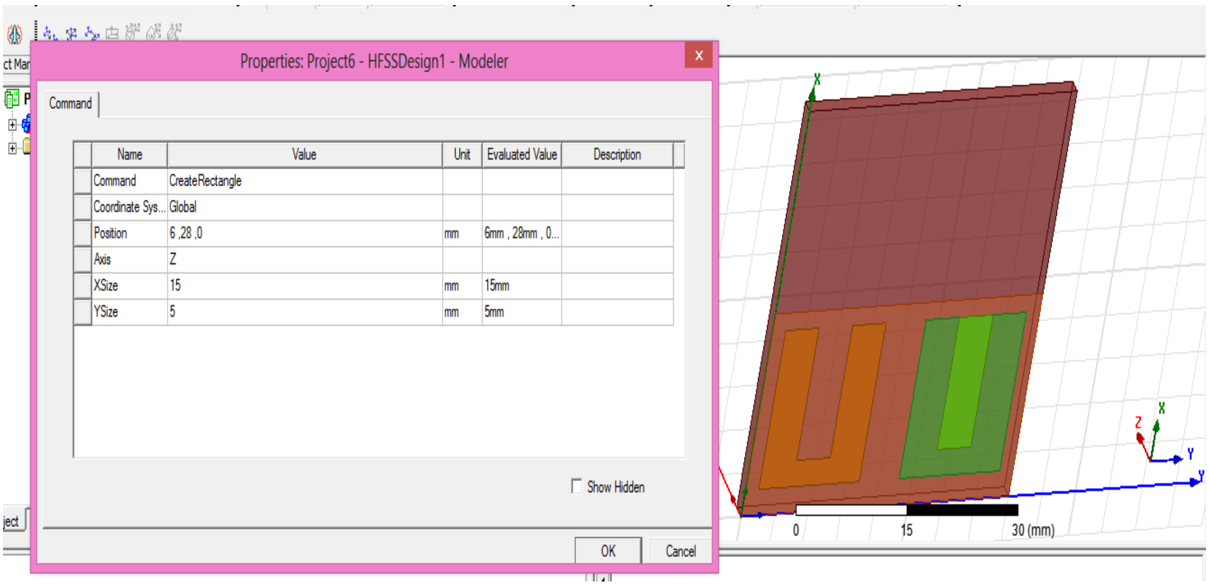


Fig 10.9 Another smaller slot in the ground plane

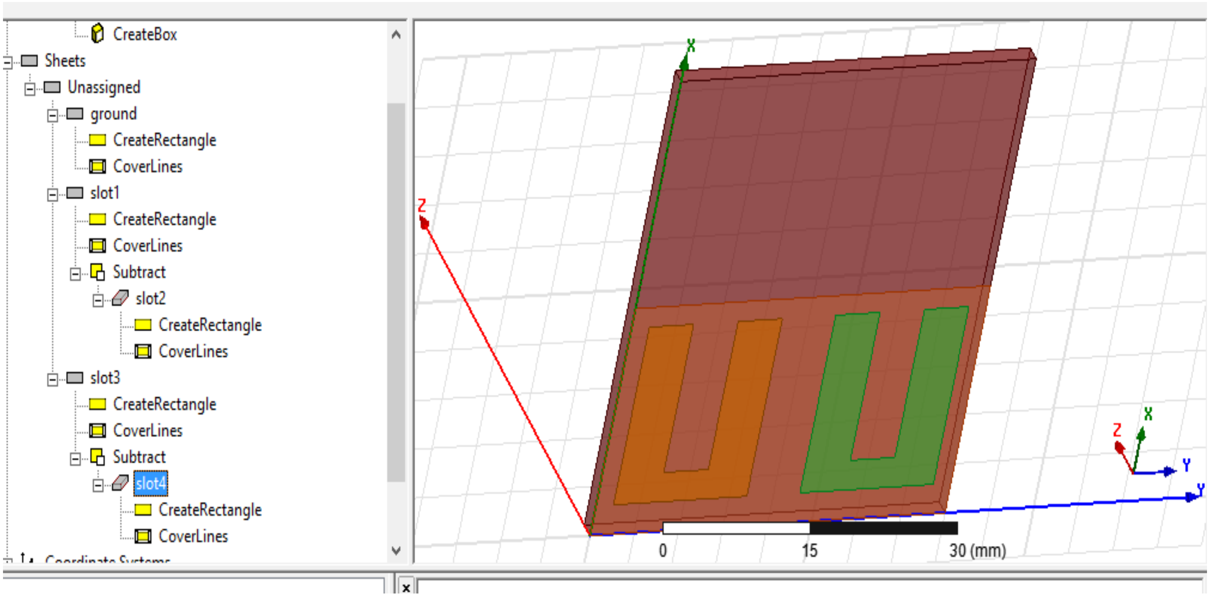


Fig 10.10 Two U-shaped defects in ground plane

Step 6- After the design of U-shaped defects subtracts these two slots from the ground plane and assign perfect-E boundary to all the slots.

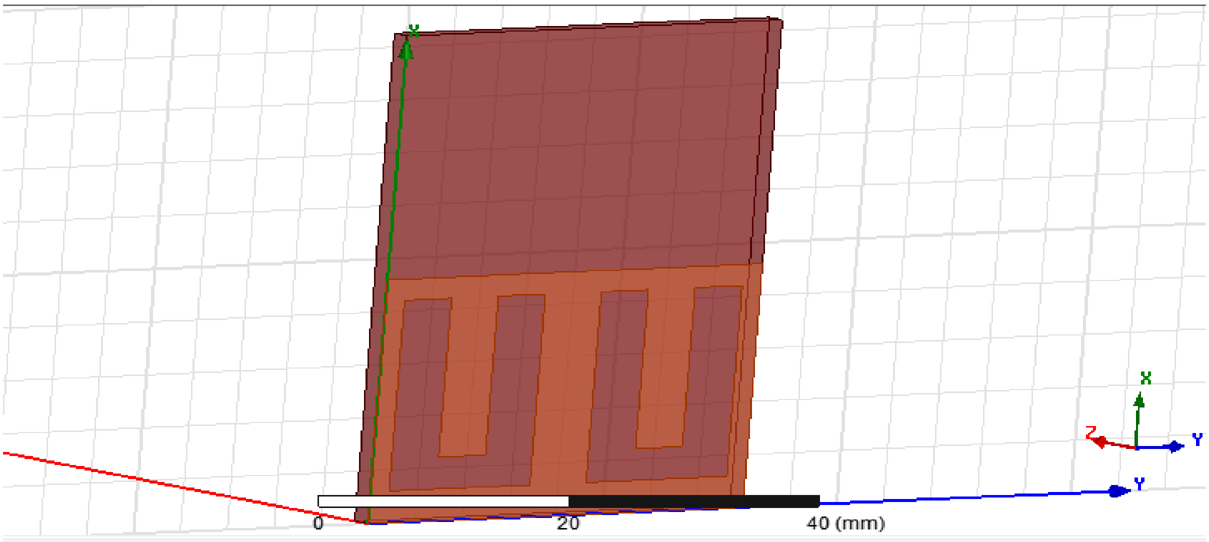


Fig 10.11 Subtract U-shaped defects from the ground plane

Step 7- Now design feed line having dimensions of 24.96mm and 3.4mm respectively and assign perfect–E boundary to the feed-line also. But construct feed-line in inverted X-Y direction. It means at one axis of substrate there is a ground plane with its defects and at another inverted axis there is Y-shaped patch with integrated feed-line.

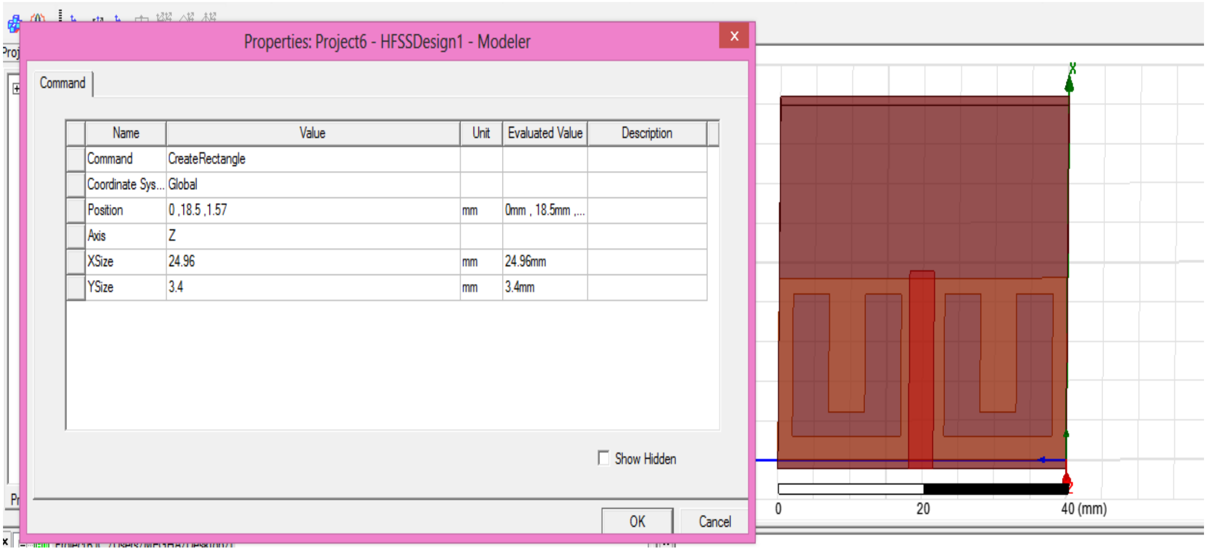


Fig 10.12 Feed-line with its dimensions

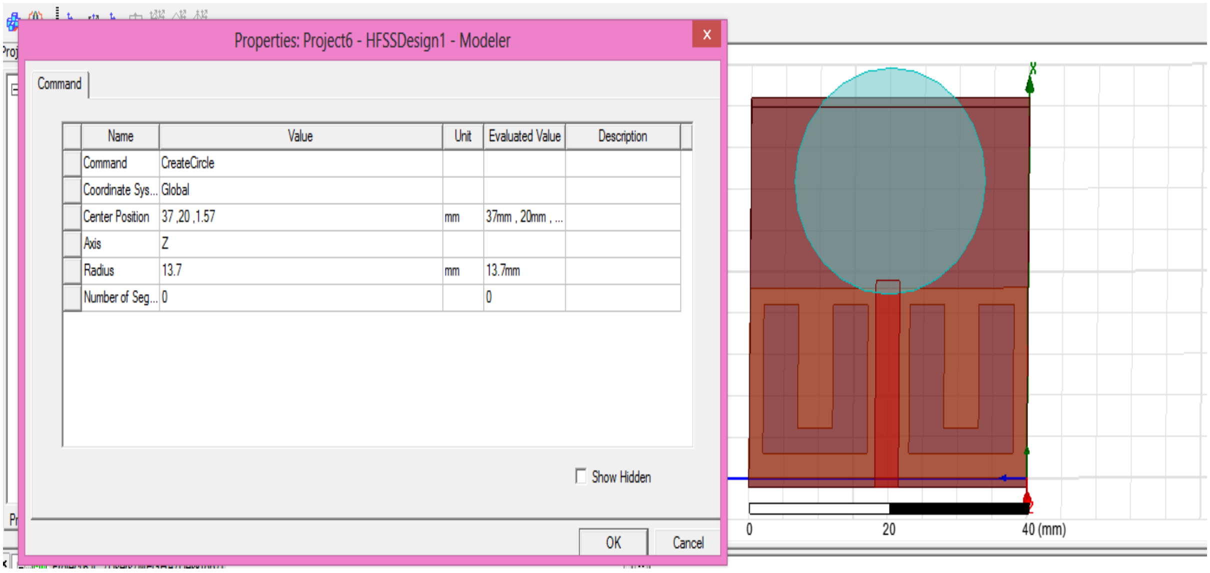


Fig 10.13 Circle united with feed-line

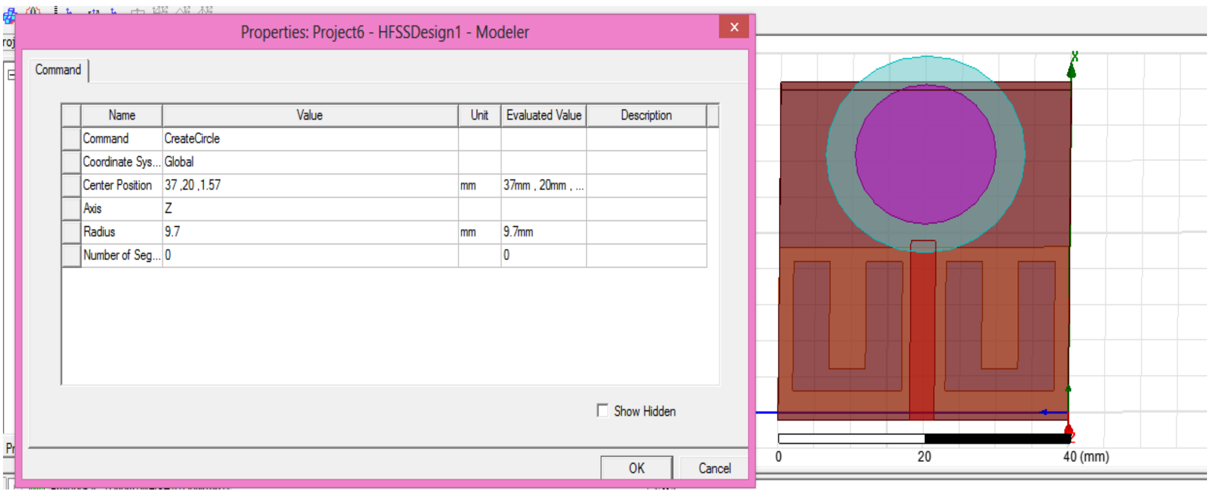


Fig 10.14 Another circle united with feed-line

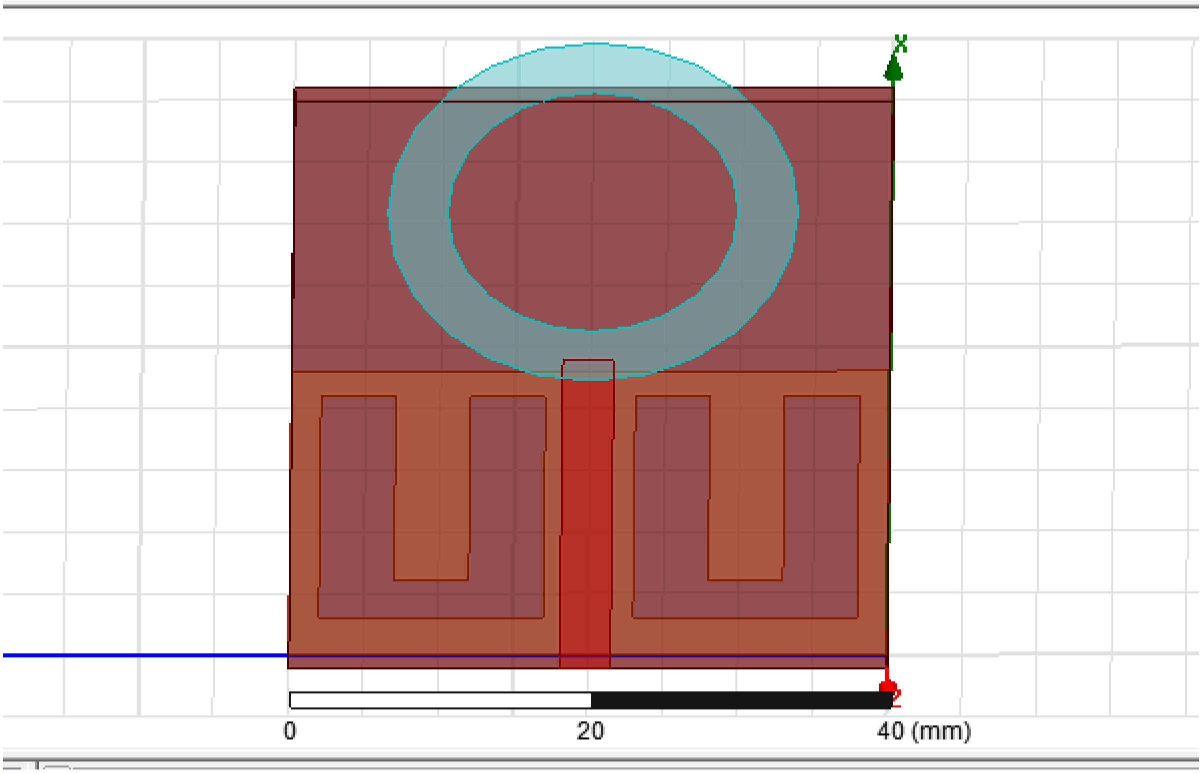


Fig 10.15 Subtract bigger circle from smaller circle

Now we draw rectangle to remove extra portion of two circles and unite both circles to the feed-line and we get Y-shaped patch integrated with the feed-line.

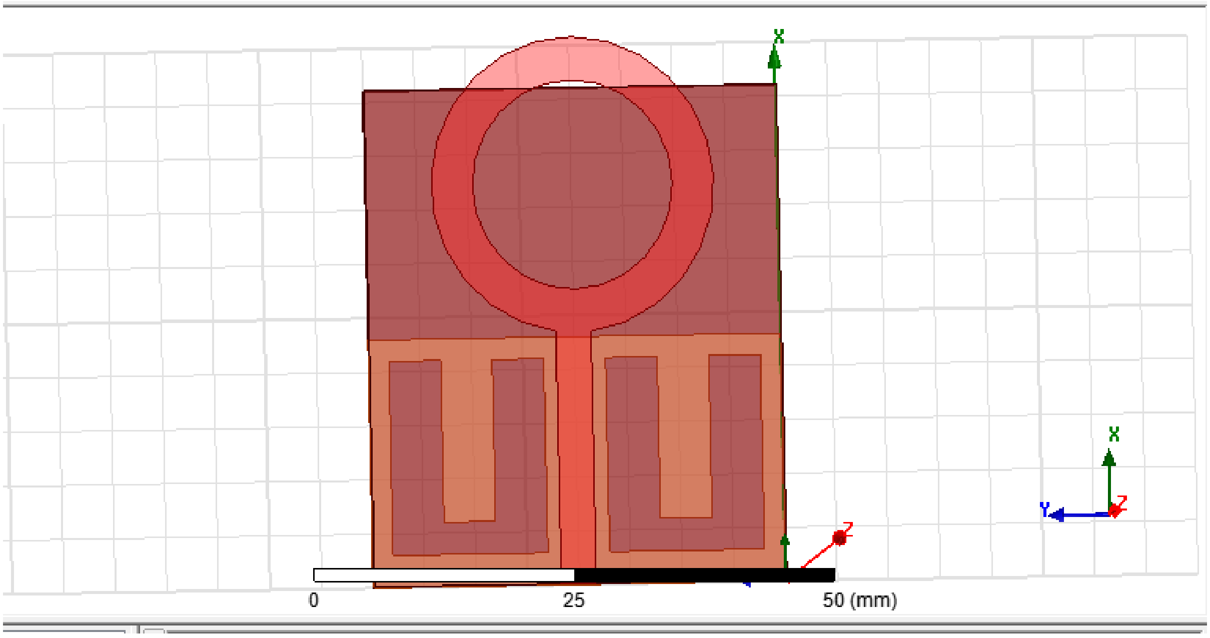


Fig 10.16 Y-shaped patch with a feed-line

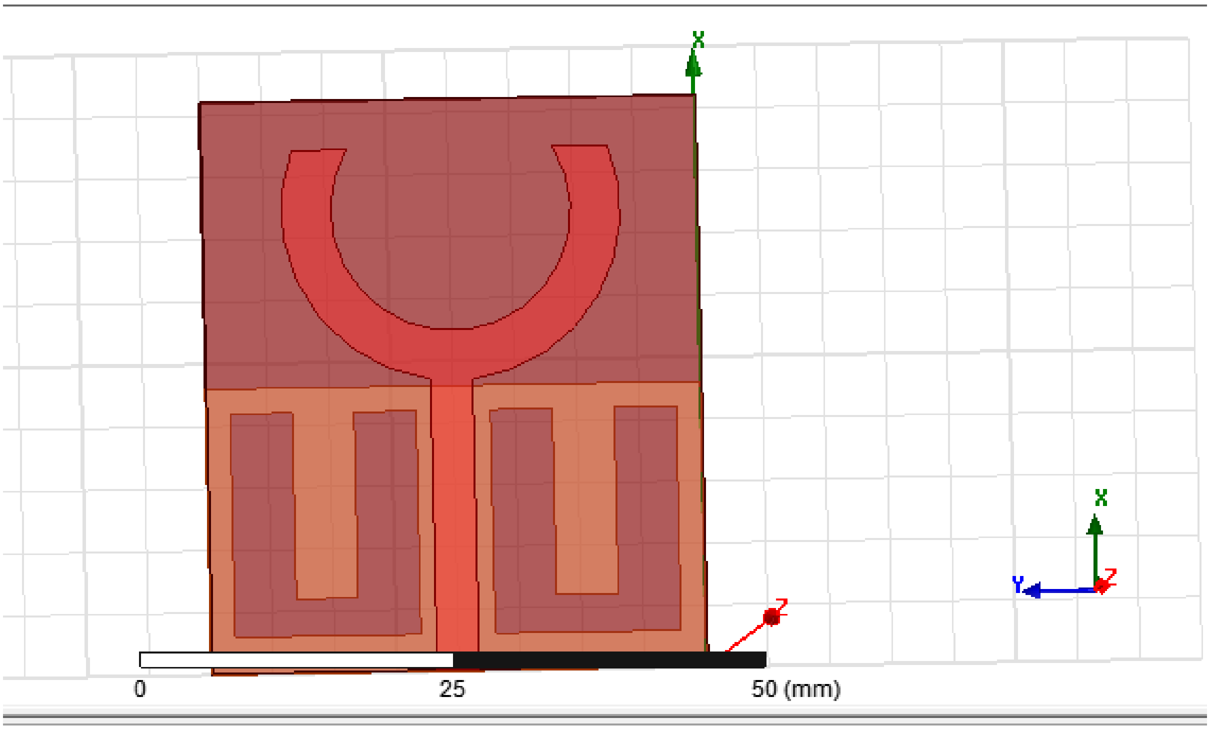


Fig 10.17 Complete design

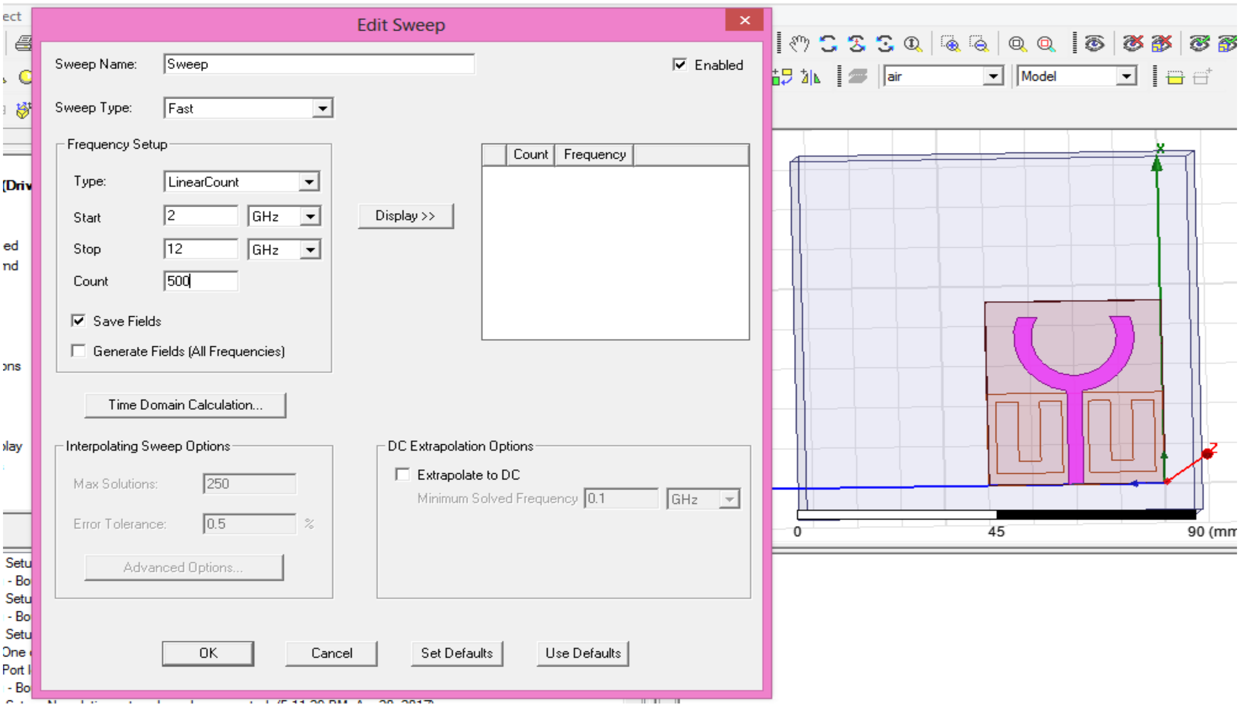


Fig 10.18 Add frequency sweep

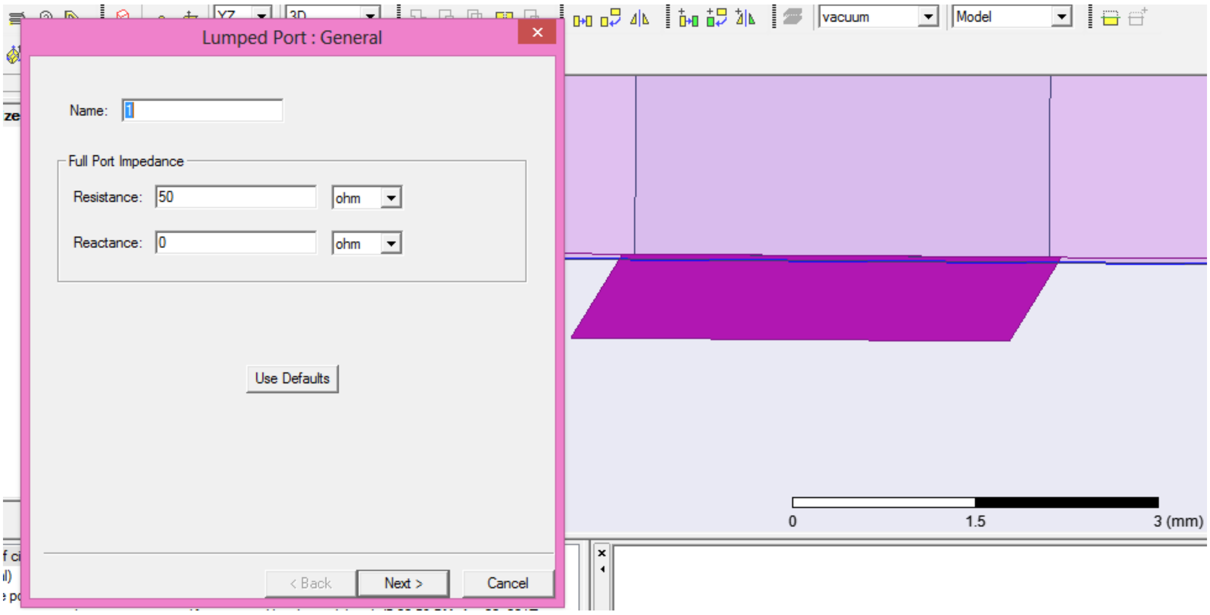


Fig 10.19 Design of lumped port

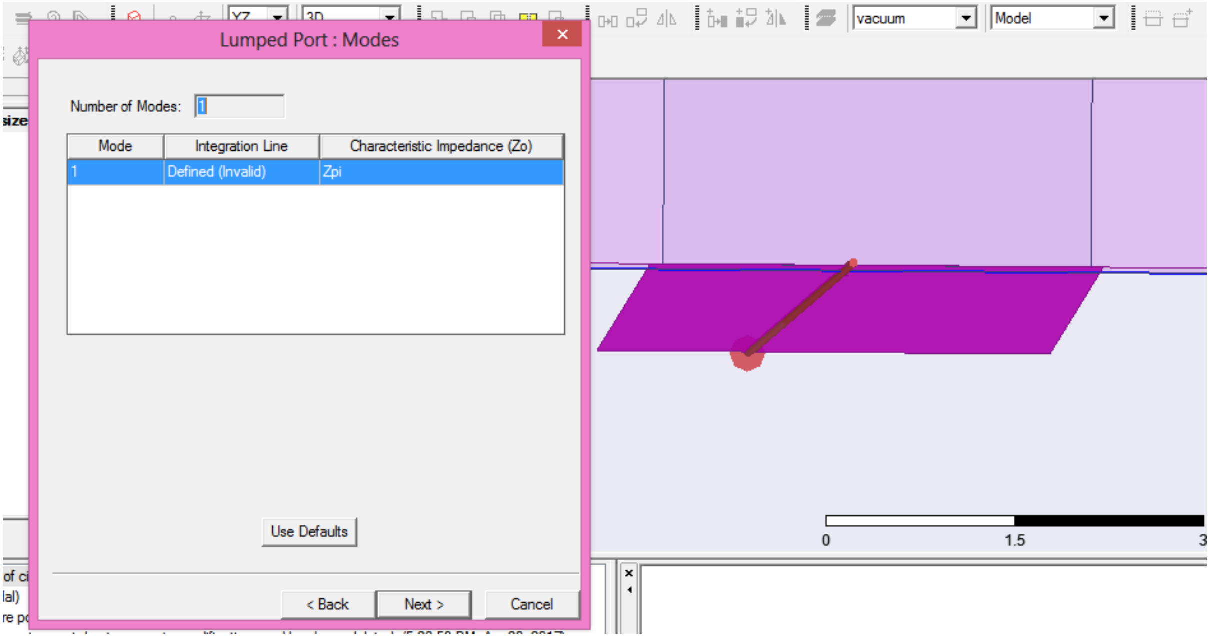


Fig 10.20 Excitation as lumped port

After making port and given excitation as lumped port. We make an air box of vacuum material and give boundary as radiation. And we verify the validation check as shown in the figure. Green tick shows all the design criteria is fulfilled and then we can draw its return-loss parameter and gain related plots etc.

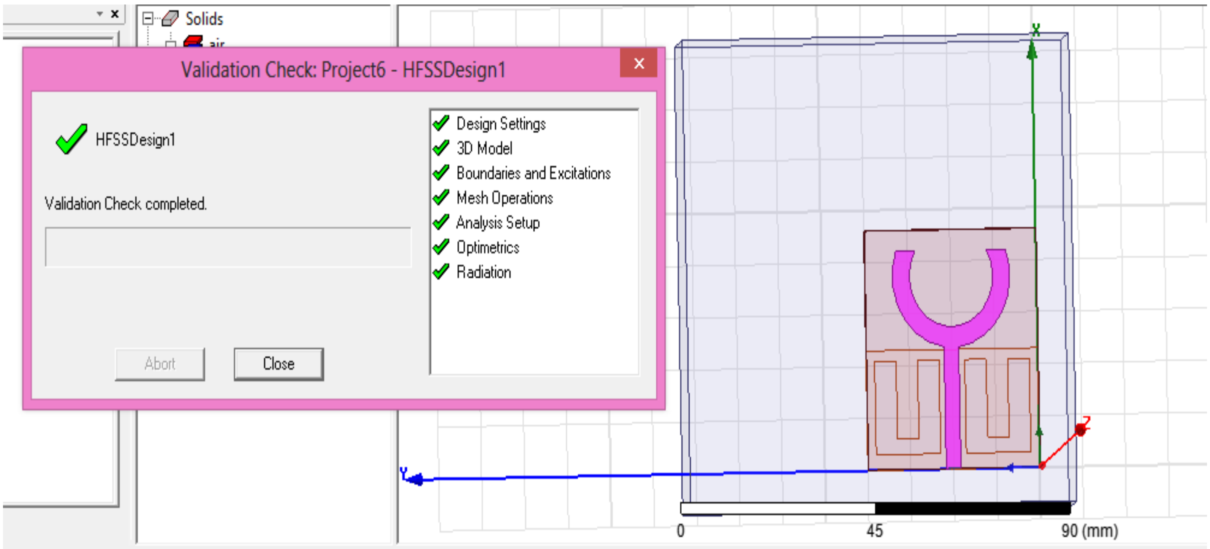


Fig 10.21 Analyze and verify the simulation

CHAPTER XI

RESULTS AND SIMULATION

11.1 RESULTS

The proposed antenna and its parameters have been analyzed by ANSOFT HFSS software. Fig 11.1shows the measured return loss characteristics of the complete design. It is defined as the amount of power utilized because of impedance mismatch between feed-line and load. Return loss parameter for an ideal antenna should be as minimized as possible. The resonant frequencies are 3.3 GHz and 7.5 GHz and the return loss parameter at these resonant frequencies are -36 dB for 3.3 GHz and -26 dB for 7.5GHz respectively. The operating bandwidth is 2.51 GHz for frequency band starts from 2.87 GHz to 4.38 GHz and for another frequency band which starts from 4.79 GHz to 12GHz is 7.21 GHz respectively.

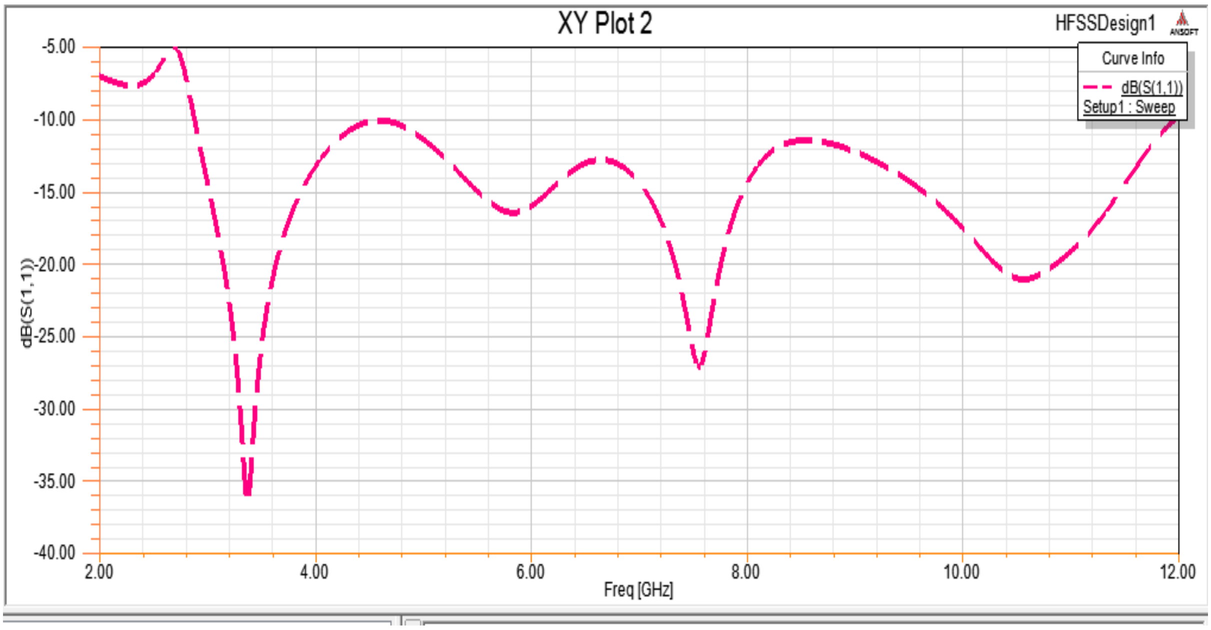


Fig 11.1 Reflection coefficient of proposed antenna

Fig 11.2 shows VSWR characteristics for the given antenna. From the graph we can see that for the entire multiband antenna from 2.87 GHz to 12 GHz the value of VSWR is less than two. It is expressed as a quantity that shows how good the given system is matched or not. It also has a relation with reflection coefficient which shows the amount of power reflected by given antenna. Its value for an ideal antenna is positive and low.

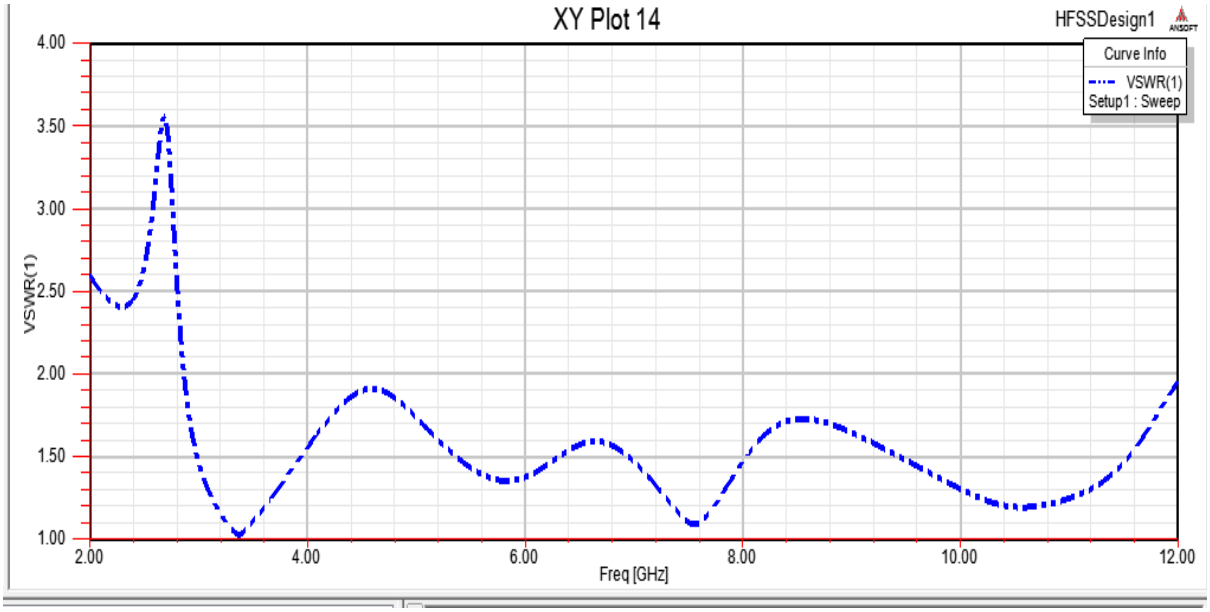


Fig 11.2 Plot showing voltage standing wave ratio (VSWR)

Fig 11.3 shows the graph that how the feed line varies as we change the length and width of feed line. The original feed-line length is 24.26mm and width is 3mm. Then we increase the feed-line length by 0.3mm but there is no change in the characteristics. But as we increase the length by 0.7mm and width by 0.3mm the return loss characteristics gets changed and the gain is also gets increased. After the optimization the new feed-line length is 24.96mm and width is 3.4mm. The resonant frequency changes from 3.3GHz to 3.1 GHz and from 7.5GHz to 6.8 GHz and the return loss at these resonant frequencies are -33 dB for 3.1GHz and -39.63 dB for 6.8GHz respectively.

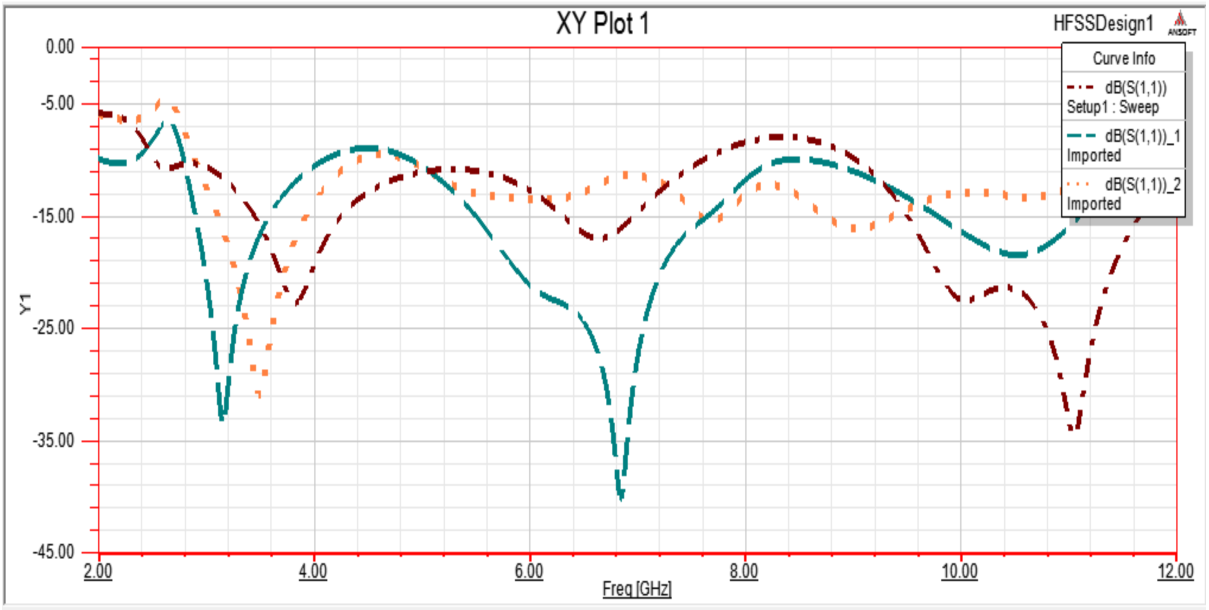


Fig 11.3 Variation of reflection coefficient as the feed line characteristics changes

Fig 11.4 shows change in the radius of the radiating patch .The original dimension of inner circle is 9mm and the dimension of outer circle is 13mm. Firstly we increase the inner and outer radius by 0.4 mm and we get the (S11>-10 dB) which is shown by red colour line. There is no effect on gain in this red line curve. Then we increase the size of outer circle by 0.7mm and that of inner circle by 0.7 mm we obtain the blue colour curve of return-loss characteristics in which we get resonant frequency as 3.3 GHz and 7.5GHz respectively. In this we get return-loss characteristics (S11<-10 dB) which is required for antenna design.

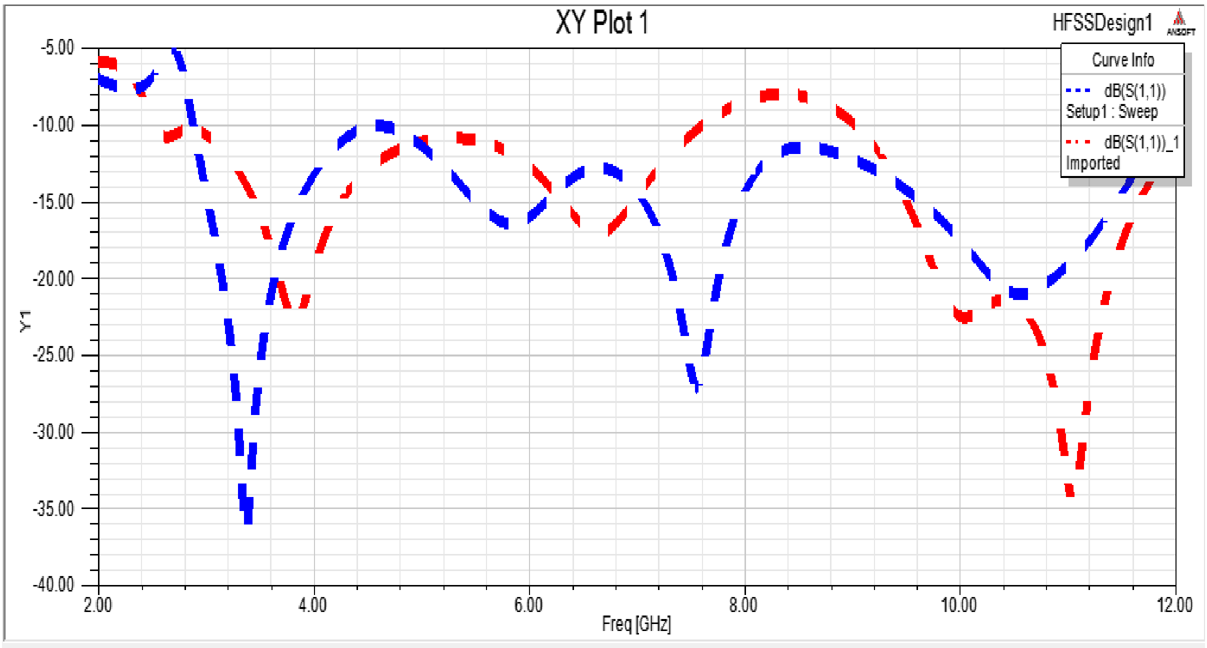


Fig 11.4 Variation of reflection coefficient with the change in radius of circle

Fig 11.5 shows as we change the shape and dimensions of patch we get the pink colour graph in which we get three resonant frequencies with increase in the return loss parameter. In this first resonant frequency obtained is 3.2 GHz and second is 5.9GHz and third is 7.2 GHz respectively. As we change the resonating frequency gain is also changed. Resonant frequency has a direct relation with the gain parameter that with increase in resonant frequency the gain starts increasing.

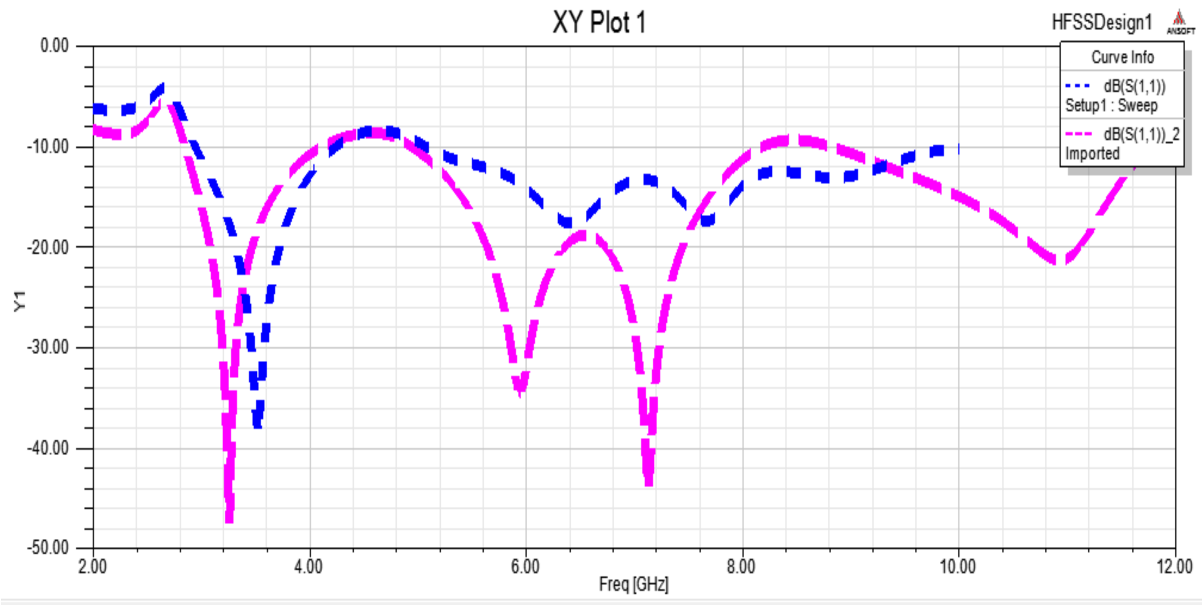


Fig 11.5 Variation of reflection coefficient as shape of patch changes

As there is a change in the dimensions of U-shaped slot in the ground plane there is no effect on return-loss characteristics and the gain parameter.

Fig 11.6, 11.7 shows current field distribution at resonant frequency 3.3 GHz and 7.5GHz. Current distribution describes that which part of the radiating patch should be responsible for specific frequency. In fig11.6 the blue region indicates the high density of current distribution or we can say that direction of flow of current can be determined by this blue colour.

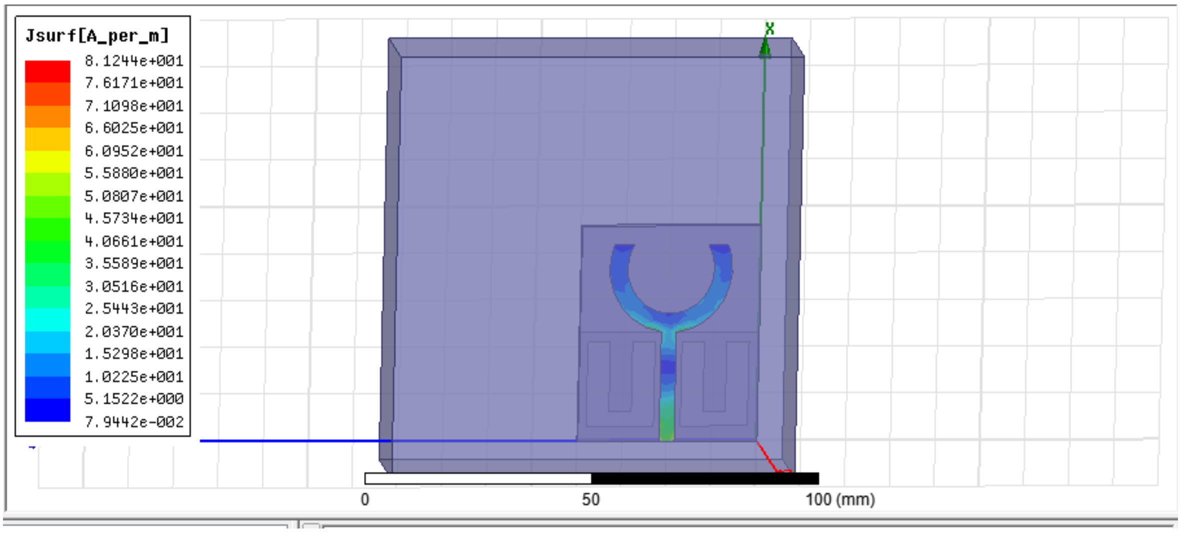


Fig 11.6 Current distribution at 3.3 GHz

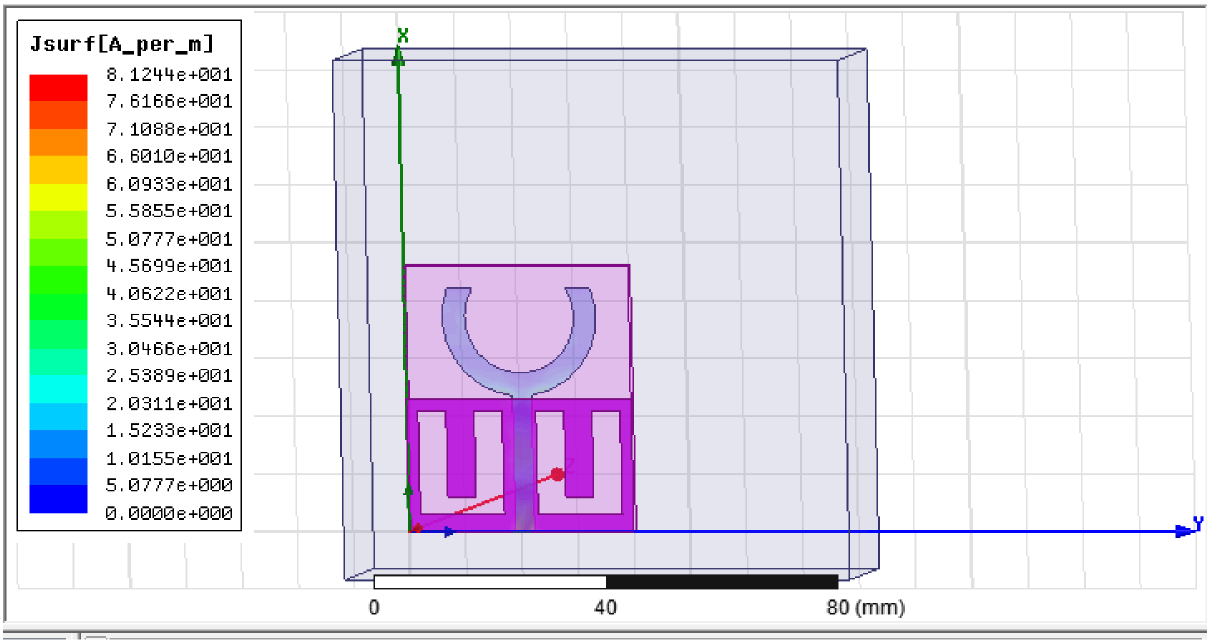


Fig 11.7 Current distribution at 7.5 GHz

Fig 11.8, 11.9, 11.10 shows radiation pattern of E-plane at different frequencies. E-plane can be determined by taking phi as 0 degree and theta as all values which is shown by figure 11.8, 11.9, 11.10. Radiation pattern shows that how the antenna is represented graphically in different directions of theta and phi. Receiving and transmitting property of antenna is described by the radiation pattern. The radiation pattern obtained is Omni-directional pattern in this design.

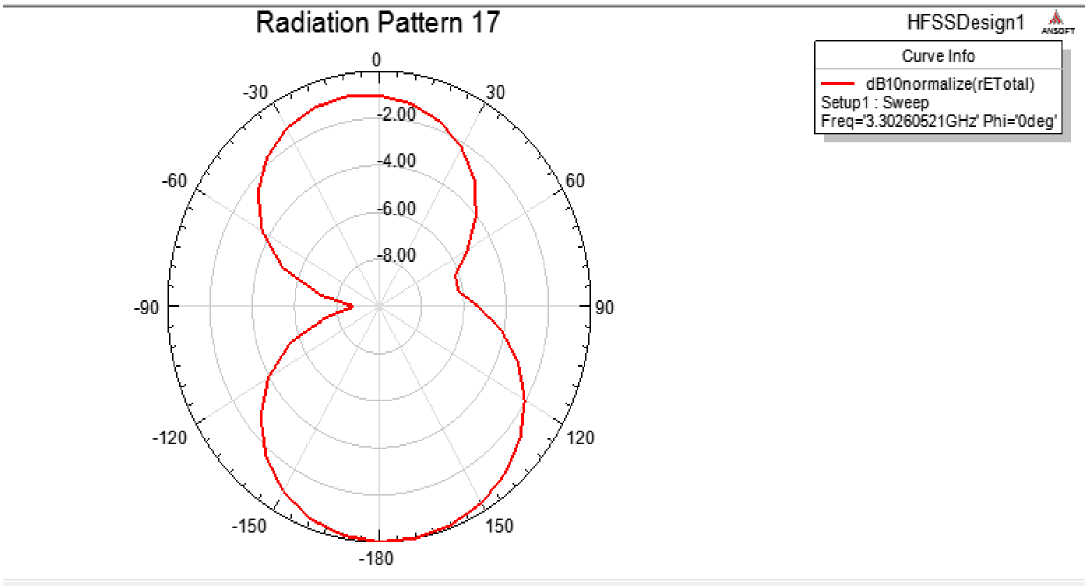


Fig 11.8 E-plane at 3.3 GHz frequency range

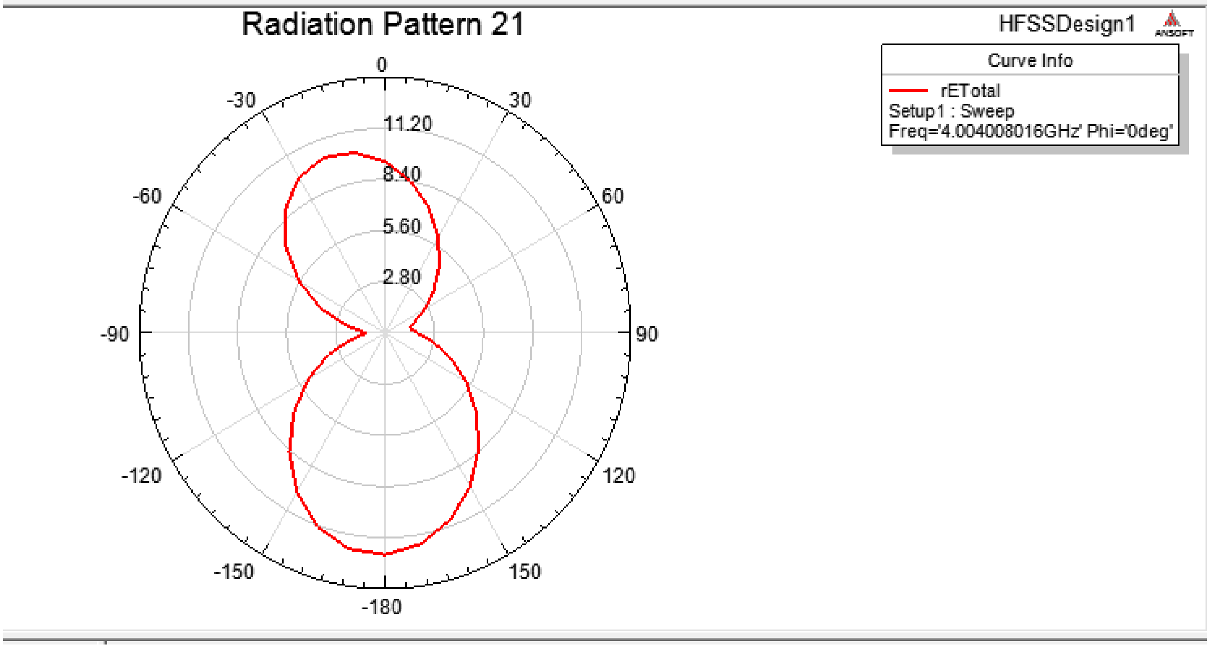


Fig 11.9 E-plane at 4 GHz frequency range

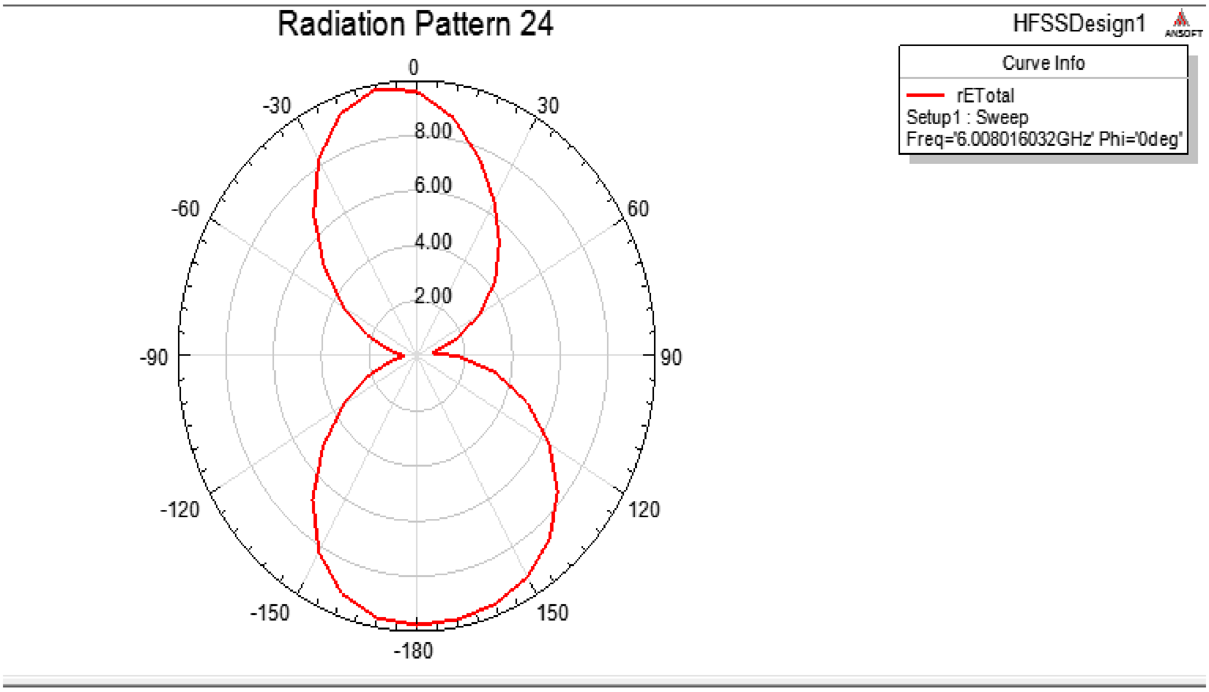


Fig 11.10 E-plane at 6 GHz frequency range

Fig 11.11, 11.12 shows 3-dimensional polar plot for 3.3GHz and 7.5GHz frequency range. As we can see from the diagram that maximum gain for 3.3 GHz frequency range is 7dBi for all values of theta and phi. Variation of theta angle lies from 0 to 360 degree with a step size of 10 degree and variation of phi angle lies from 0 to 180 degree with a step size of 10 degree. And for 7.5 GHz frequency range maximum value of gain is 5dBi which is shown by red colour in fig.11.12.

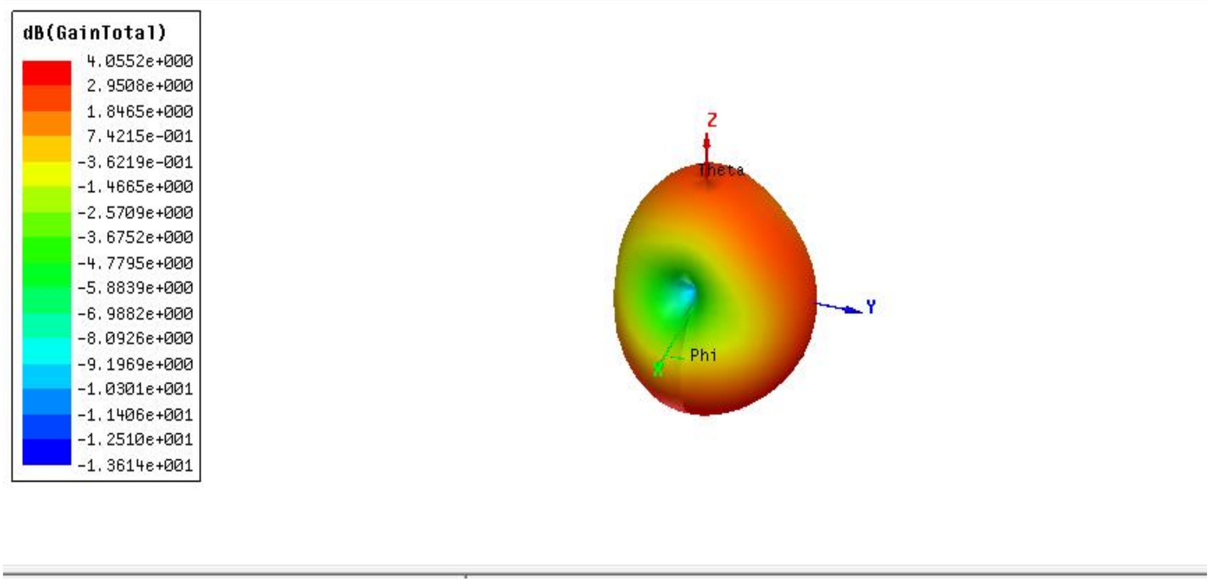


Fig 11.11 3D polar plot at 3.3 GHz

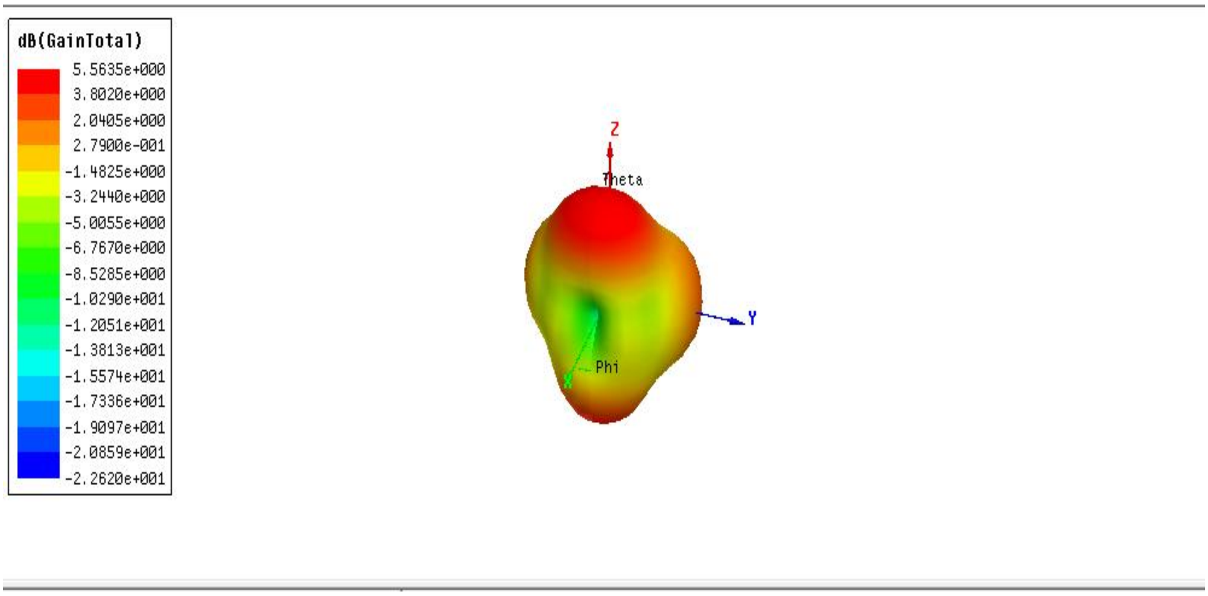


Fig 11.12 3D polar plot at 7.5 GHz

CHAPTER XII

CONCLUSION AND FUTURE SCOPE

12.1 CONCLUSION

A novel type of antenna design is proposed in which its ground plane is defected by adding two symmetrical U-shaped slots etched from it. The proposed antenna is acceptable for the various applications like WLAN, WIMAX, satellite and X-band. The proposed antenna has achieved enhanced return-loss, better impedance matching and good radiation pattern. The radiation pattern obtained in this paper is Omni-directional for the two resonant frequencies. As we can analyze the effect of increasing and decreasing each and every dimension of antenna so it can be emerged as an excellent candidate for wideband generation of wireless application.

12.2 FUTURE SCOPE

In this design two symmetrical U-shaped DGS has been used which is helpful to broaden the impedance bandwidth of a conventional microstrip-fed antenna .The given antenna is applicable for WIMAX, WLAN and X-band applications. WLAN and WIMAX are further used in hand-held devices like in mobile and also in intelligent and computer networks.

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